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Concrete Blocks.

It is hardly necessary to point out that at the present time the amount of definite information concerning concrete blocks as a structural material is almost nil. Although a great deal of attention has been drawn to them, this publicity has been due mainly to makers of machines for producing the blocks rather than to the makers of the blocks themselves. Accordingly, while all sorts of statements are put forth by men who have more or less knowledge about the subject, the fact remains that an architect or engineer who wishes to find out what is the average safe load that a wall of hollow concrete blocks will carry cannot secure any information on the subject except from a very few tests which prove little. As a result of this uncertainty, we may expect various somewhat startling building regulations, like those in one large city where a wall of concrete blocks can be loaded until its factor of safety is but a small percentage of the factor permitted with any other structural material. This particular regulation is minutely detailed and decorated with numerous technical frills, so that it looks very imposing to the casual reader, but it is safe to say that a fair mud brick made for an adobe hut would pass all its requirements. And if a few samples of this primitive building block passed the requirements, the building laws of this particular city would allow the material to be used in structures up to six stories in height. It is safe to say that no fair building regulations for concrete block construction can be drawn until more information concerning all kinds of blocks is available, for the attempt to prepare them at present will result in but trifling protection to the public or in undue favoritism to some particular type of block.

The uncertainty concerning the strength of such blocks is not surprising when it is considered that they result from dry mixtures, which are very rarely so strong as wet mixtures. The dry mixtures have to be employed on account of the nature of the manufacturing process. The material is made up with only enough water to give it the consistency of molding sand, and very few engineers will hold that with such a limited amount of water it is possible to develop the full strength of the cement. Accordingly resort is had to curing, or the retaining of the block in a moist state for some time. It is unquestionably true that this curing increases the strength of the concrete by furnishing extraneous water to assist in the hardening process. It may be safely asserted, however, that curing will never produce a concrete so strong as one prepared from a wet mixture, and at the present time it is probable that concrete specialists generally estimate a concrete block is not more than three-fourths as strong as a mass of concrete of the same proportions prepared from a wet mixture. This is a matter of conjecture, however, and until comprehensive experiments are made to determine the facts it is idle to discuss details.

Apart from the questionable subject of strength, however, concrete blocks present no features that are not well known. Dry one-to-four mixtures have been employed for many years in making what the Germans call fine cementware for decorative purposes. When properly made it is durable and attractive, as has been repeatedly shown in work executed in this country. For example, Mr. R. F. Tucker constructed about five years ago a large amount of ornamental work for a large building on the St. Lawrence River. The location of the structure is such that the summer temperature is very high and that of winter very low. During the building operations the thermometer readings on the scaffolds in summer were sometimes over 100° while in winter they fell to 40° below zero. Although this range is excessive, the fineness of the surfaces and angles has not been affected in any way. The same thing is true of the wide range of ornamental work done by the Aberthaw Construction Co. during a good many years, which is particularly instructive because it is exposed to the trying climatic conditions of New England.

It is also generally conceded that a dry mixture is not such a good resistant to moisture as a wet mixture. Although in some dry climates, like that of Colorado, it is entirely safe to plaster directly on walls built of concrete blocks, the most experienced users of them in most climates prefer to put the plaster on a furring, just as is done with brickwork. Experiments in plastering directly on a hollow concrete block wall have proved unsuccessful so often that it is a practice to be deprecated. On the other hand, solid concrete walls have proved perfectly safe for plastering. The most interesting experiment of this sort with which The Engineering Record is familiar is the house with solid walls built by Mr. Charles A. Matcham several years ago and already described in this journal. In many respects this house may be considered typical of good concrete construction. Although the walls have now been exposed during several winters, the plastering has remained unaffected. No report has yet been received of any moisture appearing on the inside surface of the 8-in. curtain walls employed in reinforced concrete buildings, although a great many of them are now in use. Perhaps one of the best tests to which a concrete wall was ever subjected was given the 12-in. basement walls of the Robert Gair building (Eng. Record, March 3, 1905) in Brooklyn a few weeks ago. A large water main in the street on which the building stands burst and flooded the vicinity. The basement remained perfectly dry and the only signs of moisture were at a few bolt holes left when the forms were removed, which had been plugged with cement mortar. On the opposite side of the street the thick brick walls of other buildings leaked like sieves.

Summing up the situation as it appears to the engineer at present, the strength of the concrete building block is not sufficiently well known to enable the architect and engineer to decide definitely how much of a load it will safely bear; it can be used with entire propriety in many places because of the knowledge of dry-mixed concrete that is already available, but it should not be employed under heavy loads until its strength is dedetermined. If well made it will be a durable material under severe weather exposures, but it must not be considered more moisture-proof than ordinary brickwork. As experience in its use and knowledge of its physical properties increase, very likely the range of its use will widen. At the present time, however, those who have the best interests of this important new material at heart will do well to urge its use for the many purposes to which it is eminently adapted and will not try to force it into competition with stone masonry and high-grade brickwork in places where loads are heavy. The hollow concrete block is such a useful addition to our building materials that its future should not be jeopardized in even a slight degree by ascribing to it all the properties of wet concrete cast in molds.

Validity of Contracts Covering Alternative or Otherwise Uncertain Items.

The attempts which have been made within the past year to invalidate two large contracts for public works in the City of New York have brought into marked prominence certain features in the award of competitive contracts, which cannot fail to interest engineers deeply. One of these attempts was made to set aside the contract awarded to MacArthur Bros. for the construction of the Cross River dam in the Croton basin. Although as a matter of formality phases of corruption were charged by the parties attempting to upset the contract, the decision of the court rested entirely upon the contention of the plaintiff that the work involved in the construction of the foundation of the dam was not set forth with sufficient definition to afford fair competitive bidding. The second of these two cases is that of the Manhattan Bridge. The contract for the construction of the superstructure having been awarded to the Pennsylvania Steel Company, a taxpayer's action was begun by an unsuccessful competitor with a view to invalidating the award of the contract mainly on the ground that provisions of the contract permitted either nickel-steel or carbon-steel to be used in certain portions of the structure at the option of the Commissioner of Bridges or of his engineer. It was argued that such an optional use of alternative materials prevented fair competition, and afforded opportunity for collusion in such a way as possibly to increase the cost of the structure illegally, and correspondingly enhance the profits of the contractor. The former suit has resulted in the maintenance of the award of the contract under which the Cross River dam is now being built. The second has been decided adversely to the City in the Appellate Division of the Supreme Court, but an appeal has been taken.

With the increase in the magnitude of public works contracts many of the conditions under which work has to be performed, or under which choice of material has to be made, have become so complicated and depend so largely upon facts disclosed subsequent to the award of contracts, and which cannot be determined prior to that award, that there has unavoidably come into existence a rather wide class of conditions requiring such alternative bidding as that described above. The indetermination as to quantities of excavation for the foundation of Cross River dam, and the consequent indetermination of the amount of masonry to be laid in that foundation was absolutely unavoidable. No matter what extent of borings or other examinations may be made at the site of such a masonry structure, the quantity of soft rock or other unsatisfactory material to be removed to obtain a suitable support for the superincumbent masonry, cannot possibly be determined until the actual excavation is undertaken. As that work progresses, and the foundation bed is uncovered so as to enable the character of the latter to be determined by actual observation, a decision may be reached as to the volume of material to be excavated, and of the masonry which will replace it, but not before. Under such circumstances, therefore, no engineer can specify even approximately as to the items, either of excavation or of masonry.

It is fair to assume that no engineer would attempt to pronounce judgment as to the strict legal character of the indeterminate amounts of material to be excavated, or to be put in place under such circumstances, but it is a condition which confronts him, and a condition with which he must deal with good sense and sound judgment. Whether the resulting alternative provisions in the contract are legal or not, the alternative procedure is the only possible one to take, and the court wisely decided that the award was legal and the contract valid.

Practically the same general principle is involved in the taxpayer's action, now being litigated for the purpose of establishing either validity or invalidity of the contract recently awarded to the Pennsylvania Steel Company for the superstructure of the Manhattan Bridge across the East River. While the mere production of nickel-steel is no longer a matter of experiment it may not be ascertainable whether a year or a year and a half hence it will be commercially advisable to use a smaller quantity of the more expensive metal or a larger quantity of the less expensive metal, i. e., of carbon-steel. At the present time there are certain questions of shop manipulation in connection with the use of nickel-steel, as well as questions of unit cost, which it may not be advisable to settle prior to awarding the contract with which, or in connection with which, it is only good business and sound public policy to give a competent engineer of repute optional powers. The precise quantities of nickel-steel and carbon-steel which must be used in either case are clear and well defined. There is no uncertainty as to the amounts of alternative materials required. Whether, strictly speaking, the clothing of an engineer or a commissioner with the power of such an alternative choice is legal or illegal, must be settled by the courts, but it will probably be found in the end that even the court decision upon such a point will be based rather upon good sense as to the best public policy than upon a strictly technical application of complicated legal principles.

Such provisions, giving the engineer choice as to methods or as to materials, are not new. They are found in many lump sum contracts or in connection with lump sum items of other contracts, which have been awarded for various classes of public works in the City of New York, and doubtless in other cities. They are wise and involve no imprudent assumption whatever. They do involve the assumption that there is a reasonable degree of morality existing on the part of the Commissioner, the engineer, and the contracting parties, and it is difficult to conceive of any conditions of a workable character which do not assume at least as much as that. Every reasonable precaution to secure the honest and efficient execution of any contract must be taken, but it certainly would not be either sensible or consistent with good public policy to surround the award of a contract with such drastic and unreasonable safeguards against corrupt practices as practically to prevent the execution of the contract. Good business and sound public policy require a proper balance between those provisions creating safeguards and those securing the execution of the work. Safeguards so extreme in character as to prohibit provisions imperative for a reasonable expression of the quantities of work to be performed, or procedures to be followed, are, it is ventured to affirm, neither good business nor good law.

When Contract Work Is Advisable.

Some readers of this journal have been somewhat surprised, to judge from letters they have written, that The Engineering Record believes in executing a considerable portion of the Panama Canal by contract. It may be well to repeat, therefore, the arguments advanced in these pages from time to time for contract work. The contractor has become a specialist; he is often an engineer by training and generally has engineers associated with him. Where any kind of construction must be carried on which requires training and experience, the contractor is a business necessity, or the kind of services he can render must be obtained from salaried men. If there is construction work always in progress and the company does not object to being burdened with detail, the addition of salaried experts and a large number of men to its pay rolls has unquestionable advantages. But if the work is done once for all, as a sort of temporary departure from the company's usual operations, then the contractor is the main reliance in securing economical construction. This is true whether the contractor is paid a lump sum for the completed work or is given a salary or is paid a retaining fee.

There has long been a tendency to avoid the contract system in much of the construction for individuals and smaller corporations. A prominent New York builder is frequently given carte-blanche to erect an important building, the owner often insisting that he only shall do the work, the price paid being cost plus a fixed sum, which is essentially a retaining fee, or an agreed percentage, which is essentially a salary. This condition arises partially from special confidence in a particular contractor, but mainly from the fact that the difficulties of estimating closely on complicated work are so great that bids will vary greatly and the chances are about equal that the lowest bidder will be one whose ability is not well recognized, or who will take great chances and either delay the work or slight it in the endeavor to come out ahead or fail absolutely to carry it out, involving delay and complications in reletting.

There are many classes of work on which it is almost impossible to estimate closely as to time as well as cost. In the case of the Broadway cable road in New York, the first undertaking of its kind in the city, it was absolutely impossible to tell what difficulties or delays would be met. It was built on the percentage basis. If bids had been invited they would certainly have varied greatly and the lowest would probably have been vastly in excess of the actual cost of the work, to enable the contractor to cover the chances involved. In the construction or reconstruction of large and valuable buildings, the loss of rentals and interference with business becomes so great that excessive prices can well be paid to secure prompt results. For this reason the work on great buildings has often been pushed night and day at greatly increased cost. By the successful execution of such extensive and difficult work some contractors and contracting firms have secured the confidence of capitalists to such an extent that they can command their own terms and select their own work.

The impression that contract work must necessarily be the most economical is not always justified, however. The contractor's interest in making a profit generally results in hurrying the work so that "day's work" has come to be regarded as slow work. Everything, however, depends on the individual, his ability and experience and the breadth of his view. Many contractors fail to recognize that just so many men must usually be employed to keep the work moving, that the contract becomes a permanent boarder and costs just so much per day or week, whether much or little is accomplished. The failure to appreciate this fact makes some contractors too saving in the expenditure of money and often results in serious loss to them. When the details are clearly known it almost always pays to push the work rapidly to completion. When the details cannot be clearly defined and when the work must move slowly and with some uncertainty, wise contractors will hesitate to undertake it except on a percentage or cost plus a fixed sum basis.

In cases where the owners have competent engineers and architects, the decision as to which system shall be followed may very wisely be left to these men. This is what owners have the right to expect of engineers and architects employed by them, and if they cannot have sufficient faith in them to intrust the decision to them, they should secure professional men in whom they can have perfect confidence.

The monopoly of large and difficult work, which the more powerful contracting firms deservedly possess, makes it more difficult, perhaps, to secure competent men to undertake the smaller works, while at the same time it leaves room at the bottom of the ladder for the new and less wealthy contractors who often take as much or greater interest in the small jobs as the more prominent contractors do in the large ones. A corporation with much small work on hand, embracing several classes of work in each job, found it economical to divide the work. Its engineers and architects undertook the task of connecting the several portions, and kept peace and harmony, so to speak, between the several tradesmen. The result was that a saving was effected of from 10 to 30 per cent. in the cost of the work. In the case of the Panama Canal, a large part of the work will be of a simple character. It would unquestionably be performed by the Isthmian Canal Commission itself, but to do so would involve the perfecting of a construction organization of great scope subject to the various laws which govern federal employees. Such organizations are already in existence; they are made up from top to bottom of selected and trained men who are willing to work for private contractors for less money than they would insist on receiving from the government. This journal doubts if it is good business to burden Chief Engineer Stevens with the responsibility of gathering and training a great construction force when one can be obtained from contractors of the highest reputation. Mr. Stevens will have the full measure of duties that any engineer should carry if his responsibilities are confined to engineering and appearance before the various congressional committees which threaten to make his office an intermittent nightmare.

Some Septic Tank Phenomena.

There is no portion of the report of the experiments conducted last year at the Columbus sewage testing station which is of more general interest to engineers than that relating to the results of the investigations to determine the character of the changes occurring in the septic tanks. The opportunities for running comparative experiments between plain sedimentation and septic action were utilized and consequently the amount of definite knowledge concerning the differences between the two is considerably advanced. Probably to a small number of specialists this information contains little that is new, yet to the engineer whose time for technical reading is limited and who rejoices when he feels that he skips none of the high points of professional progress, the reported results are highly instructive. The investigations were made in five tanks. Three of these were 40 ft. long, 8 ft. wide, and about 8 ft. deep. A fourth was circular, 12½ ft. in diameter and 5½ ft. deep, and the fifth was a boiler shell 15 ft. long and 6 ft. in diameter, in which an effective depth of 5 ft. was maintained and from which a pipe led to a gas meter for registering the amount of gas given off. The closed tank was supplied with screened sewage, and the others with screened sewage which had also passed through a grit chamber. It was thus possible to reproduce the conditions which have been urged by various engineers as desirable for securing satisfactory septic action.

In considering the results it is important to bear in mind that they refer only to Columbus sewage and Columbus conditions. On this account no attempt should be made to apply them elsewhere without a careful study of the voluminous data concerning the raw and septic sewages and the conditions of the experiments, which are given in the report. In a general way, however, they confirm results obtained elsewhere. For instance, it has been established that from 8 to 17 days were necessary for septic action to become established in a tank, the period being shortest in summer and longest in winter. It has also been shown that the formation of a well-defined scum is not an invariable accomplishment of septic action, for in no instance was such a scum formed regularly, although during periods of strong gas ebullition quantities of sludge were brought to the surface. At such times a spongy mat, several inches thick, was formed, which gradually broke and settled to the bottom. The evolution of gas in the closed tank when run at such a rate that its contents were displaced every eight hours ranged from 1.5 to 7 per cent. of the volume of the sewage treated, depending on the season. In a general way the investigations showed that no noteworthy change was effected by the tanks in the amounts of dissolved matter. This is true of periods of 24 hours in the tanks as well as those of shorter duration. The amount of free ammonia increased from 3 to 34 per cent., averaging 17 per cent. and being greatest during the time the septic action was most evident. The amount of fatty matter removed was from 6 to 59 per cent. The increase in the bacterial content of the sewage was apparently not associated in any direct way with the amount of gas evolved or the season of the year. At no time were offensive odors noted about the septic tanks, and when they were cleaned at the end of the tests, in June, remarkably little odor was given off from the sludge.

The main interest in the results to most engineers is in the information they furnish concerning the accumulation and liquefaction of the sludge. The percentage removal of suspended matters being practically identical in the settling and septic tanks it seems permissible to compare directly the two sludge deposits to secure information concerning the degree of hydrolysis in the septic tanks. In the plain settling tank the deposit amounted to an average of 3.3 cu. yd. per million gallons and in the septic tanks to 1.33 cu. yd. The sludge liquified in the septic tanks therefore amounted to 60 per cent. on an average, of the total amount deposited in them. The closed tank, receiving crude sewage, showed 50 per cent. reduction in the solid matter deposited as sludge, and this was accordingly considered to be a fair average figure to use in the designs of the Columbus disposal works. It is too low a figure for warm weather and too high for cold. It is important as affording one more carefully determined proof that the old claim of complete removal of sludge by the septic tank is wholly unwarranted.

One lesson of the tests which is very evident is the importance of guarding against the passage of the sludge into the effluent. This is particularly likely to occur when the ebullition of the gas is violent. On account of the clogging action which such suspended sludge causes in the finishing filters receiving septic sewage, the utmost care is warranted in designing septic tanks to reduce this objectionable feature so far as possible. In some places attempts have been made to overcome the difficulty by passing the effluent of the septic tanks through coke filters before it is applied to the finishing filters, and in other cases supplementary subsidence has been suggested. Most engineers will agree with the Columbus engineers, however, that the most practical manner to get around the difficulty seems to be to prevent the sludge from reaching the outlet end of the tank by providing suitable submerged baffles and scum boards.

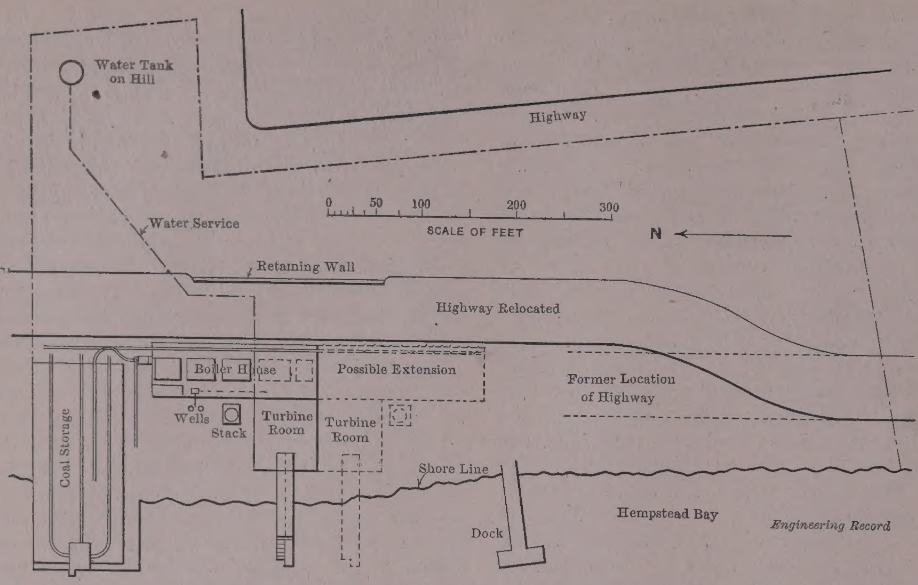
An Old Lesson in Public Franchises.

The troubles that have arisen over the contract for the superstructure of the Manhattan Bridge bring to mind the earlier difficulties which the city experienced with the initial stages of its important bridge projects. These are interesting as showing the importance of a minute scrutiny of all franchises and the importance of looking ahead at their effect on public undertakings. Public officers cannot generally be depended on for the enthusiasm and eagerness necessary to promote difficult or unpopular enterprises, and the legislative procedure apparently necessary to get good things is distasteful if not impossible to such officials, even if their other duties do not bar them from such efforts. It results naturally that franchises are obtained by men of much ingenuity and astuteness, whose methods and names might operate adversely to securing the desired privileges if these alone were used. It becomes necessary, therefore, to secure special rights which will in themselves float the undertaking and permit a liberal admixture of water in the stock. It is a mistake to assume that much money is paid by these men for franchises. Expenses there must be, and often large ones, but the skilled promoter trades, threatens, promises aid for aid, and brings to bear personal influences and friendly ties in a manner which works wonders.

When the first bridge was projected over the East River at New York about 1869 a charter was secured by a private company of about fifteen subscribers. Among these were William Tweed, Peter B. Sweeney and R. B. Connelly, whose names afterward became sufficiently notorious. About $500,000 was subscribed to build a bridge that cost $15,000,000. It is not known whether these men ever expected to build this bridge themselves; possibly they thought they could. Within a few years the cities of New York and Brooklyn became subscribers to the stock of the company to the extent of about $5,000,000, work was begun, and the original individual subscribers were paid about $500,000 for their holdings, which had probably cost them very little money. The projector and moving spirit in the enterprise, the man who had advanced the legislative funds, was subsequently paid $125,000, nominally for salary as superintendent of the bridge for less than one year, but actually and avowedly to reimburse him for the preliminary expenditures. Thereafter the cities built the bridge and now own it. The individual interests were entirely extinguished by the cash payment of about $600,000, which may be said to be about the actual price paid for the charter to the energetic men for saving the officials of the city the trouble of doing the disagreeable but apparently necessary work in the legislature.

In 1891 a few brilliant and experienced men obtained a charter for two new bridges over the East River. There is no evidence whatever that these men did not intend to build both of the bridges; they certainly began work in apparently good faith and did some important preliminary work in securing rights of way and the like. The business depression of 1893-94 made it difficult to raise money for any public work. Brooklyn was suffering bitterly for want of better communication with the greater city and her mayor had a bill introduced in the legislature to permit the two cities to build one bridge, the more important of these two, so that threatened delay might be avoided. The old company had so strengthened itself in the legislature that the bill could not pass without its aid. This was given on the tacit understanding that the cities should purchase the charter for the bridge crossing the river from the foot of Broadway, Brooklyn. The bill was passed, a commission was appointed, and an effort made to find a site for the bridge which would not encroach on the rights of the old company. This was obviously impossible, as it would be claimed that any bridge would seriously damage the company by making it impossible for it to build; in other words, the legislature had given the old company a valuable charter and then protected it by a law providing that it could be purchased, or, if necessary, condemned. Some people asserted that the old charter had expired because requirements for work had not been complied with; the courts, however, as in the case of penalty clauses in contracts, are quite averse to enforcing confiscation of private property. To condemn the old charter would be slow; it might last several years, during which the troubles of Brooklyn would counterbalance the $200,000 which the company charged, and of which it had spent perhaps three-fourths for surveys and other work. The commission of the two cities accordingly decided in 1895 to purchase the charter of the company at the price named.

The purchase of this charter under the circumstances was a wise act on the part of the commission. Long delays, litigation expenses and the award of damages might easily exceed the sum that was paid, while the commission secured important rights, which it could not easily obtain short of condemnation, in being able to locate its bridge properly. The moral of this experience with the two bridges is that cities are almost surely the gainers in attending to their own business, securing their own franchises and avoiding the use of legislative middlemen, who are not in business merely for their health or amusement.



General Plan of Power Plant of Nassau Light & Power Co.

THE NEW LIGHTING AND POWER STATION AT GLENWOOD.

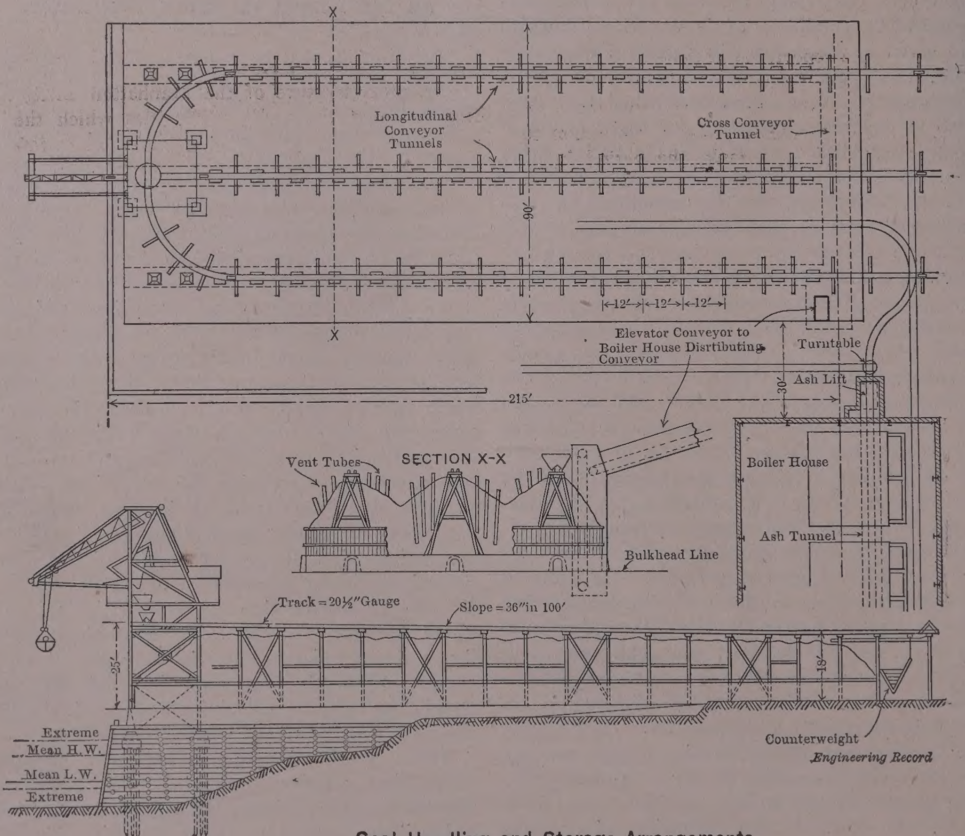
The Nassau Light & Power Co. is engaged in the generation and distribution of electric current for lighting and power purposes over a large section of Long Island, comprising the greater part of Nassau County, including the towns of North Hempstead, South Hempstead and Oyster Bay, from Long Island Sound to the Atlantic Ocean. The business of the company is of a suburban character, for which reason the alternating-current system of distribution is used exclusively, with 6,600-volt, long-distance transmissions and 2,200-volt, local distribution. The power station of the company was located until recently at Roslyn, originally a nearly central location for the distribution system. The equipment there consisted of one 100-kw and two 150-kw alternating-current generating units belt-driven by reciprocating engines, which were operated condensing by the use of cooling towers. Owing to increased demands on the station there were added in 1903 two 400-kw Westinghouse-Parsons turbine units. Owing to the further rapid growth of the business, however, it soon became evident that still greater capacity would be needed, and it was accordingly decided, late in 1903, to construct a large station of modern design. The steam turbine was selected as the prime-mover for the new plant, enabling the two 400-kw. turbo-generators at the Roslyn station to be utilized, and owing to the desirability of high vacuum for condensing operation, it was found expedient to relocate the station in close proximity to tide water to secure a plentiful supply of circulation water. The new station is some four miles from the former plant, at Glenwood, on Hempstead Bay, an inlet from Long Island Sound. Here there is plentiful supply of circulating water for condensing purposes, and also an excellent harbor, which permits shipments of coal and machinery to be received directly by boat. The site embraces nine acres of ground with a water front of 900 ft. and averaging 400 ft. in width. At the north rear corner of the site there is a hill rising about 75 ft. above high water level, on which a storage tank for a gravity water supply has been constructed. As a highway passed through the site of the boiler house, it was moved 80 ft. to the eastward, the foot of the hill being graded away and retained by a concrete retaining wall.

The boiler and turbine rooms are parallel to the shore line and highway. The turbine room is 68x78 ft. in size, whereas the boiler room is 175x58 ft., the two buildings thus forming an L in the corner of which is located the 200-ft. chimney. The accompanying plan shows the projected arrangement of buildings for possible future extension, if the total rated generating capacity which is possible in the present buildings, 3,800 kw., should prove inadequate. This will be made by duplicating the present structure to the southward, another 175-ft. boiler room and 68-ft. turbine room being extended in that direction from the present structure. The advantages of such an arrangement are the ease of construction of the additional steel work and ash-handling system. A separate system of water circulation conduits will be necessary, but this can easily be cross-connected with the present system so as to enable either system to be shut down for cleaning.

A troublesome factor in the construction of the plant was the sandy character of the soil, which made it difficult to secure firm foundations. Piling was necessary for the stack, the coal-handling tower and a large portion of the coal storage platform. For the machinery and building column foundations excavations were carried down to considerable depths and the footings spread. The sub-soil is a mixture of clay and sand, which was constantly wetted by multitudinous springs covering the entire site of the plant, which derived their flow from the numerous high hills surrounding the location. These conditions rendered the foundation work extremely difficult and in the case of the stack necessitated a cofferdam in order to reach the desired depth.

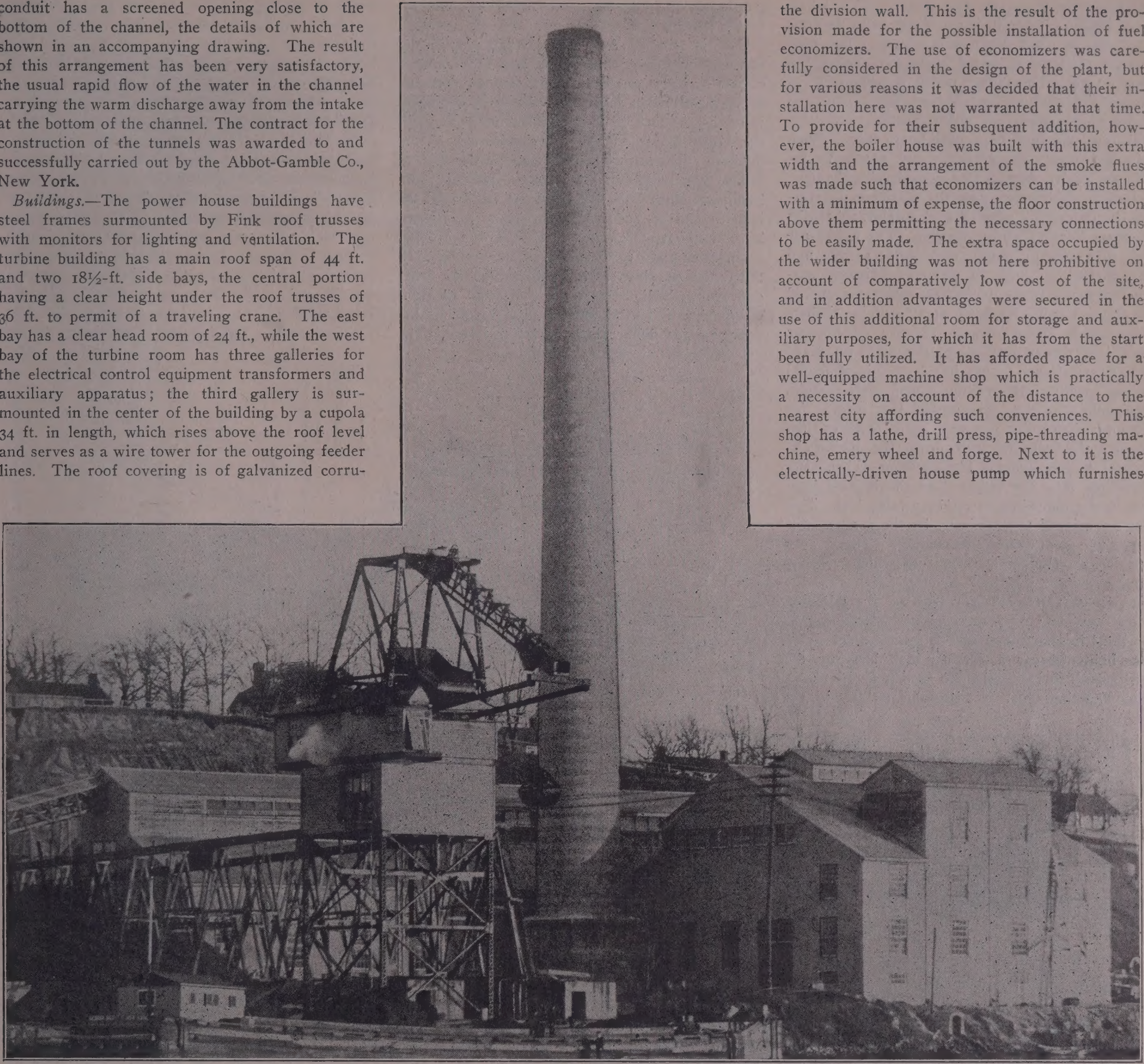
Condensing Water Conduits.—Cofferdam construction was also required for the construction of the condensing water intake and discharge tunnels, which extend from the turbine room to the pier line in the channel. Their length is 125 ft., of which the greater part is beyond the shore line, and in their construction three cofferdams were used. The work was begun on the shore end, embracing 48 ft. of the tunnels; 19 ft. of this was within the turbine room and forms a part of the building foundations. The second section was also 48 ft. in length and extended beyond the shore line, while the last was 42 ft. long and extended about 13 ft. beyond the intake opening for the purpose of completing the excavation out into the channel. In the shore cofferdams, as in the chimney foundation, considerable difficulty was experienced in caving banks and fresh water springs, while in the case of the outer cofferdam extra precautions were necessary in the strengthening and anchorage of the structure on account of the strong tidal currents and danger of contact from ice floes, barges, or other floating obstructions.

Owing to a tidal range of approximately 8 ft., rapid and almost continuous currents are encountered at this point, where the channel lies very close to the shore. As a result of these currents an arrangement of intake and discharge openings was adopted which is decidedly novel. The tunnels are carried straight out to the pier line and the discharge conduit arranged with the outlet openings on the top surface, while the intake



Coal Handling and Storage Arrangements.

conduit has a screened opening close to the bottom of the channel, the details of which are shown in an accompanying drawing. The result of this arrangement has been very satisfactory, the usual rapid flow of the water in the channel carrying the warm discharge away from the intake at the bottom of the channel. The contract for the construction of the tunnels was awarded to and successfully carried out by the Abbot-Gamble Co., New York.


General View of the Glenwood Power Plant from the Water Front.

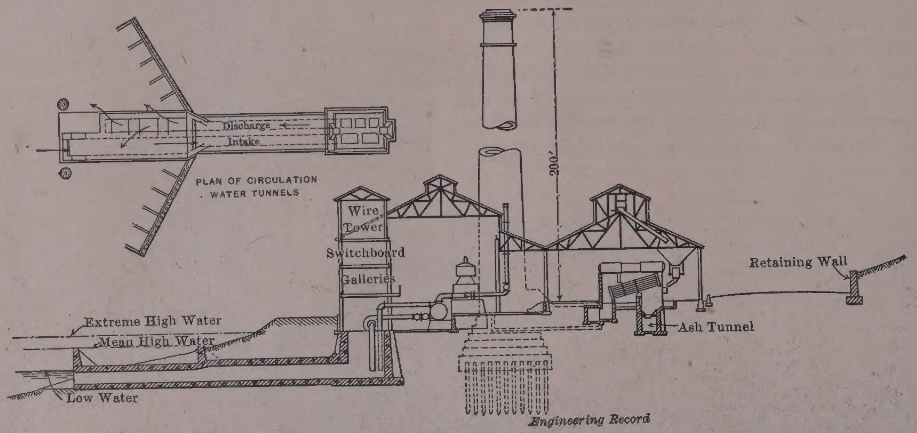
Buildings.—The power house buildings have steel frames surmounted by Fink roof trusses with monitors for lighting and ventilation. The turbine building has a main roof span of 44 ft. and two 18½-ft. side bays, the central portion having a clear height under the roof trusses of 36 ft. to permit of a traveling crane. The east bay has a clear head room of 24 ft., while the west bay of the turbine room has three galleries for the electrical control equipment transformers and auxiliary apparatus; the third gallery is surmounted in the center of the building by a cupola 34 ft. in length, which rises above the roof level and serves as a wire tower for the outgoing feeder lines. The roof covering is of galvanized corrugated iron laid on 4-in. channel purlins spaced 4 ft. apart, with a similar lining beneath the purlins in order to form an air pocket and prevent the collection of moisture of condensation from the air as would occur if a single covering only were used. This gives the advantages of a wooden roof without the fire risk incurred. The monitors are fitted wtih pivoted sash upon either side, which is operated by Lovell window apparatus, manufactured by the G. Drouvé Co. The steelwork for the buildings was framed and erected by the American Bridge Co.

The side wall construction consists of an inner lining of galvanized corrugated iron on which is mounted expanded metal, fastened to nailing strips bolted to the corrugated iron, and on the expanded metal there was plastered a 2-in. coat of cement mortar, in which was embedded, before setting, a facing of small pebbles. The floors are of concrete with granitoid finish throughout; that of the main turbine room is 4 in. thick and those for the electrical gallery floors are of concrete arched between I-beams of differing sizes and spacings, according to the loads to be carried. The first gallery floor is carried on 15-in. I-beams spaced 4 ft. 3 in. between centers, between which are sprung the concrete arches 4 in. thick at the top. It was designed for 500 lb. per sq. ft. The second gallery floor, which has similar weights and spacings of I-beams, but a 9-in. minimum thickness of the arch, has a capacity of 300 lb. per sq. ft. The third gallery or wire tower floor is carried on 8-in. I-beams spaced 3 ft. 4 in. apart for a maximum, between which are sprung concrete arches of a minimum thickness of 7 in., the capacity of this floor being 150 lb. per sq. ft.

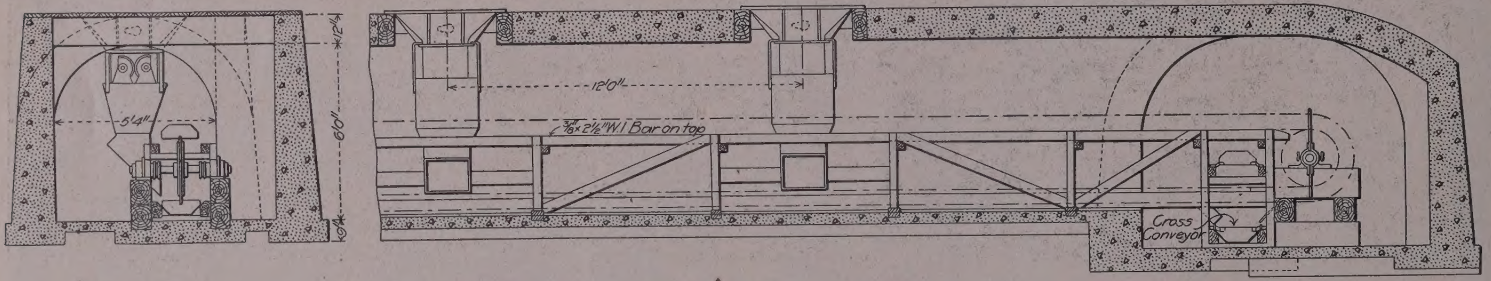
The boiler house has a roof monitor 20 ft. wide and 10 ft. high in order to accommodate the coal distributing conveyor. The roof structure carries also a row of elevated coal storage bunkers over the firing floor in front of the boilers, being assisted in carrying the weight by 12-in. posts rising at each side and in the middle of the boiler settings. An unusual feature noticeable in the construction of this boiler house is its width, there being a clear space of nearly 20 ft. between the rear of the boiler settings and the division wall. This is the result of the provision made for the possible installation of fuel economizers. The use of economizers was carefully considered in the design of the plant, but for various reasons it was decided that their installation here was not warranted at that time. To provide for their subsequent addition, however, the boiler house was built with this extra width and the arrangement of the smoke flues was made such that economizers can be installed with a minimum of expense, the floor construction above them permitting the necessary connections to be easily made. The extra space occupied by the wider building was not here prohibitive on account of comparatively low cost of the site, and in addition advantages were secured in the use of this additional room for storage and auxiliary purposes, for which it has from the start been fully utilized. It has afforded space for a well-equipped machine shop which is practically a necessity on account of the distance to the nearest city affording such conveniences. This shop has a lathe, drill press, pipe-threading machine, emery wheel and forge. Next to it is the electrically-driven house pump which furnishes the water for use throughout the plant.

Coal Handling and Storage.—The location of the station had much to do with the solution of the fuel problem and question of storage of coal, the site not having the advantage of rail connection, so that all shipments of coal have to be by water. There is a minimum depth in the channel opposite the station of 8 to 10 ft. at mean low tide, permitting coal barges to approach with ease. Water shipment has necessitated a large coal storage, however, inasmuch as accumulations of ice in the adjacent bay in the winter months are liable to render navigation impossible. Accordingly a large coal storage yard was provided at the northerly end of the site, embracing a wharf 110 ft. wide, projecting 90 ft. from the shore line with coal-handling equipment for unloading barges and delivering to the boiler room. This yard has a total storage capacity of 8,000 tons, more than sufficient to permit the operation of the station when ice is liable to cause trouble. The coal is stored in the open on a level platform of filled ground, 220 ft. long and 90 ft. wide, which extends from the end of the boiler house out upon the wharf. This wharf is of timber cribs with stone filling, with its deck 8 ft. above mean high water level. The coal storage platform is raised some 6 ft. above the wharf level. The filling, which is principally of cinders, is retained by concrete front and side walls surrounding the filled portion, and this wall is surmounted by a tight board fence, which extends around the platform and serves to retain the coal if heaped to a considerable depth.

Coal is distributed over the platform, in storing, by dump cars which travel on elevated tracks on three lines of timber trestles. The tracks are laid to a 20½-in. gauge with 12-lb. T-rails and are carried on lines of 4x12-in. stringers surmounting the trestle bents; the latter are spaced 12 ft. apart and are built up of 6x6-in. timbers with 3x6-in. braces so as to give an average height of the runway above the platform of 20 ft. Every fourth panel has 3 x 6-in diagonal braces, while intermediate panels have 4x6-in. horizontal spacers. The trestles are graded for uniform slopes of 3 per cent., so as to permit the loaded coal cars to drift down the incline by gravity to the dumping blocks, from which, after dumping they are returned to the loading hopper in the unloading tower by a cable line. This rope is gripped automatically by the car near the dumping point while descending. There is a gearing attachment by means of which a heavy counterweight is lifted by the inertia of the moving car; after the car trips on the dumping block and the coal is released, the stored energy in the lifted counterweight is effective in giving the lightened car a forcible kick back up the incline, which is sufficient to send it to the tower. The dumping block is adjustable on any of the trestles so that the coal may be delivered at any point in the yard.



General Cross-Section of the Glenwood Power Plant.



Details of Scraper Coal Conveyor in Longitudinal Tunnels.

The unloading of coal from barges is accomplished by a coal-hoisting tower with a 1-ton clamshell bucket having a capacity of 50 tons per hour, which is installed on the edge of the wharf so as to permit the boom to have a maximum reach of 19 ft. beyond the wharf line. The tower is a steel structure carried on four clusters of five 8-in. piles, driven to refusal in the filling within the wharf and capped by concrete extending 10 ft. below the surface. The tower has four well-braced latticed columns spaced 20 ft. between centers, rising to 42 ft. above the wharf level. The boom extends 28½ ft. beyond the front of the tower, having a clearance of 54 ft. above mean water level, and is pivoted so as to be swung to one side to allow masted vessels to approach the dock. The operating machinery is in a cabin 40 ft. above the wharf level and consists of a coal crusher and an Exeter double steam hoisting engine with drums for the hoisting and bucket-closing movements. In the roof of this cabin is a 5-ton receiving hopper into which the clamshell unloading bucket dumps; from here the coal is passed through a motor-driven crusher in the cabin, which discharges into a small loading hopper beneath for dumping into the trestle cars. The latter pass beneath the cabin at an elevation of 30 ft. above the wharf on a platform with a turntable, enabling the trestle cars to run from the tower out on any of the trestles.

Coal is handled from the storage pile to the elevated bunkers in the boiler house by scraper conveyors in tunnels beneath the storage platform, an elevator bucket conveyor and a scraper distributing conveyor extending longitudinally through the boiler house monitor for delivering to the bunkers. Beneath each line of trestle there is an arched concrete tunnel 7 ft. wide by 7 ft. 3 in. high, extending from the wharf 210 ft. toward the inshore end of the yard, where they are joined by a similar transverse tunnel. The longitudinal tunnels contain conveyors running underneath the outlet openings in the platform to the cross conveyor, which delivers the coal from the longitudinal runs to the boot of an elevating bucket conveyor for delivery to the boiler house. The walls of the tunnel are 18 in. thick and at the arch 12 in. Where they were built through the filled section within the wharf, pile foundations were provided for them. The conveyors in the tunnels consist of sheet steel troughs, 15 in. wide and 4 in. deep, through which scrapers attached to link driving chains are drawn. These conveyors are all operated by a 15-h.-p. induction motor located in an extension chamber near the middle of the transverse tunnel, with reduction gearing designed to drive the scrapers at a speed of 90 ft. per minute, at which rate they have a capacity of 50 tons of coal per hour.

Coal is drawn out of the piles to the longitudinal conveyors underneath in the tunnels through special outlet hoppers with double-opening segmental-gear gates and delivery chutes. These hoppers, spaced about 12 ft. apart in the longitudinal tunnels, are of heavy cast iron, 4 ft. square and 14 in. deep, and are set in the roof of the tunnel. Beneath each is a receiving hopper with delivery spout and apron for directing the coal into the conveyor trough. Poke holes are provided on all four sides, with pivoted covers to permit a bar to be inserted for dislodging the coal above and breaking up wedging or arching of the coal while flowing out. The conveyors in these tunnels are mounted on wooden runways, 33 in. high by 30 in. wide, which have iron guide plates on the upper and lower corner members, forming rails on which the scraper shoes travel and are guided when in motion. These longitudinal conveyors are 205 ft. in length and the cross conveyor is 74 ft. long.

From the cross tunnel the coal is raised by a bucket conveyor 35 ft. above the storage platform, where it is dumped into the longitudinal distributing conveyor extending into the boiler house monitor. This conveyor has 12x14-in. buckets spaced 12 in. apart on the elevator chain, which scoop coal from a cast-iron receiving hopper or boot in a pit 6½ ft. below the level of the transverse tunnel, into which the coal is dumped by the cross gathering conveyor. There is also a direct chute connection to this boot from a special receiving hopper beneath the nearest elevated trestle above, which thus permits direct handling of coal by trestle cars to the elevating conveyor for delivery to the boiler house without entering the storage piles, if desired, when coal barges are being unloaded. This latter provision is of service in obviating the necessity of double handling of the coal or in keeping different grades of coal separate. The elevating conveyor is enclosed in a No. 10 gauge steel casing with dumping spout at the top, 24 in. square, by which the coal is delivered to the boiler house conveyor, which casing is effective in preventing escape of dust and returning spilled coal back to the boot in the pit.

The distributing conveyor in the boiler house monitor is similar in design and capacity to those in the tunnels beneath the storage platform. It is carried from the delivery spout of the elevating conveyor to the boiler house monitor by a wood structure inclined at an angle of 15°, which spans the space of 27½ ft. to the boiler house wall, beyond which it is carried in the framework of the monitor. The scraper trough has dumping outlets at frequent intervals, with chutes to deliver coal into any of the bunkers over the firing floor. Each bunker is 15 ft. square at the top and 8 ft. deep, and holds 15 tons.

A traveling weighing hopper, by means of which coal may be delivered in measured lots of 1,000 lb. or less, feeds the stoker hoppers. The device consists of a cylindrical receiving hopper, 28 in. in diameter and 3 ft. high, which, with its weighing mechanism, travels on a runway of 8-in. channels beneath the undercut gates of the bunkers, thus permitting coal to be measured out from any bunker in the boiler room and delivered into any of the stokers. The scale mechanism is suspended from a frame of 6-in. channels which travels on 8-in. channel runways on four 6-in. wheels. Beneath this framing is suspended the swinging compensating links and reducing levers for the scales, on which the hopper is supported. The weighing balance arm is located in an enclosed scale box suspended within a convenient distance of the floor for reading and balancing. The car is traversed along the runway by a chain wheel mounted on one of the axles of the car, with the chain dropping within easy reach from the floor. The outlet gates beneath the bunkers are all opened and closed by chain connections reached easily from the floor. The delivery chute beneath the hopper is suspended by a ball bearing joint which permits the chute to be swiveled to either side with ease for traversing. The entire coal-handling equipment, including the unloading tower, trestle lines and automatic car operating system, tunnels and scraper conveyors, elevating and distributing conveyors and the coal weighing hoppers, was built to the designs of the consulting engineer by the Exeter Machine Works, Pittston, Pa.

Boilers.—There are at present only four boilers in the plant, although provision is made for the addition of two more. They are installed in two batteries of two each. Two are 500-h.-p., horizontal water-tube boilers, built by the Aultman & Taylor Machinery Co., and two are 425-h.-p. Caldwell boilers of a similar type, which had been used a short time at the former plant at Roslyn. The larger boilers have 5,000 sq. ft. of heating surface each, while the smaller units have 4,200 sq. ft. each. Each of the larger boilers has three 42-in. steam drums 24 ft. long and 240 3-in. tubes 18 ft. long. All are equipped with Foster superheaters capable of raising the temperature of all steam at the rated capacity of the boilers 150° Fahr.

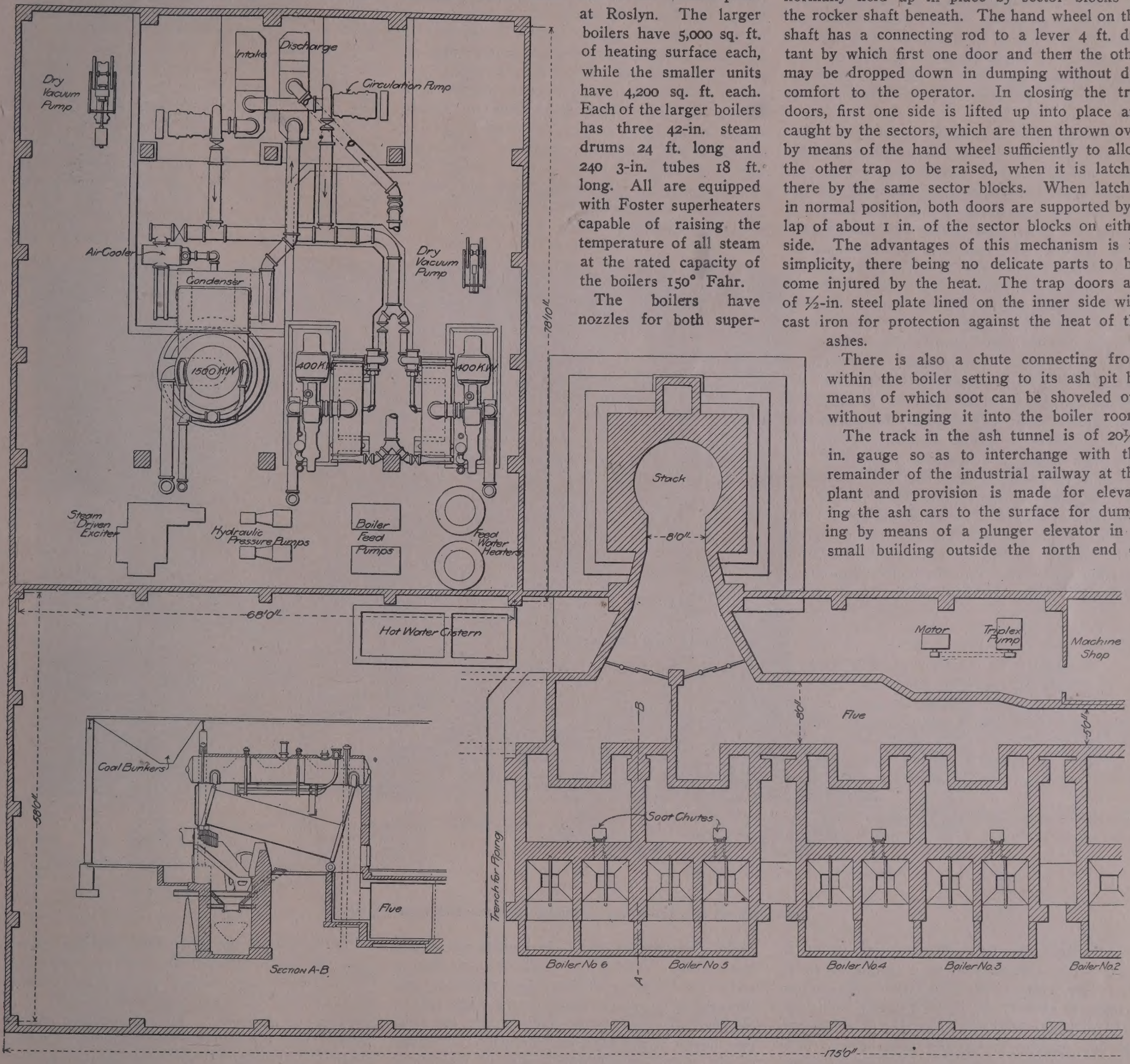
The boilers have nozzles for both superheated and saturated steam, which is delivered to the turbine room by duplicated piping systems, one for the superheated supply to the turbines and the other for supplying saturated steam to the auxiliaries. Each boiler is equipped with a Roney stoker having effective grate areas of 54 and 43½ sq. ft. for the large and small units, respectively. These stokers are operated by two Westinghouse Standard designs, with coupling connections between the sections of the driving shaft, so that either engine may operate both stokers together if desired.

Ash Handling.—Ashes are handled in a tunnel 5½ ft. wide by 6 ft. high beneath the furnace ash pits, in which cars run on a narrow-gauge track permitting the ashes to be dumped directly into them. The furnaces have ash pits 6 ft. square by 4 ft. deep, lined with fire brick. In their lower outlets there are trap-door gates of a construction to prevent buckling or warping due to heat, and to open and close freely, as illustrated in an accompanying drawing. Each pit has two dropping trap doors, each 1¼x2 ft. in size, which are normally held up in place by sector blocks on the rocker shaft beneath. The hand wheel on this shaft has a connecting rod to a lever 4 ft. distant by which first one door and then the other may be dropped down in dumping without discomfort to the operator. In closing the trap doors, first one side is lifted up into place and caught by the sectors, which are then thrown over by means of the hand wheel sufficiently to allow the other trap to be raised, when it is latched there by the same sector blocks. When latched in normal position, both doors are supported by a lap of about 1 in. of the sector blocks on either side. The advantages of this mechanism is its simplicity, there being no delicate parts to become injured by the heat. The trap doors are of ½-in. steel plate lined on the inner side with cast iron for protection against the heat of the ashes.

There is also a chute connecting from within the boiler setting to its ash pit by means of which soot can be shoveled out without bringing it into the boiler room.

The track in the ash tunnel is of 20½-in. gauge so as to interchange with the remainder of the industrial railway at the plant and provision is made for elevating the ash cars to the surface for dumping by means of a plunger elevator in a small building outside the north end of the boiler room. This elevator has a lift of 12 ft. and at its upper level connects through a turntable with the coal tracks or a track extending to the rear of the building for dumping to fill.

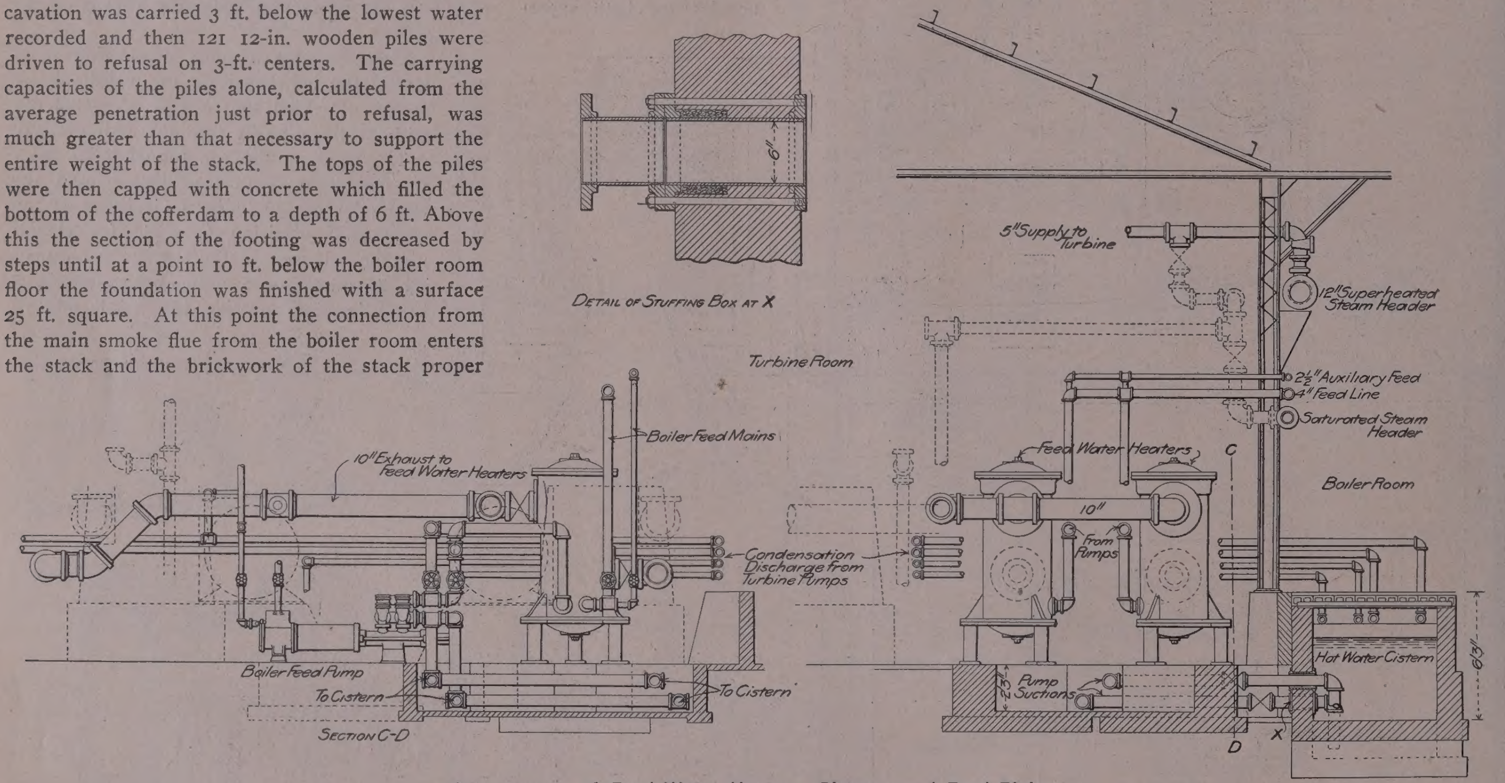
Flues and Chimney.—The smoke flues and connection to the stack are beneath the boiler room floor in the space at the rear of the boiler settings. Each boiler has a 4x6-ft. flue extending down from the rear of the setting to the main flue, which is of substantial construction, firebrick lined, 8 ft. in depth and varying in width from 5 ft. opposite the first battery of boilers to



Plan of the Power House, Showing Under-Floor Smoke Flue Connections to Stack.

8½ ft. opposite the third. The stack connection is taken off directly at the rear of the third battery and is 7½x18 ft. in cross-section at the dampers. The double damper used at this point consists of cast-iron plates bolted together to form half dampers, each 4½x7½ ft. in size. They are ribbed for strength and are mounted on square spindles which turn in ball bearing step pivots at the bottom. The two dampers are operated in unison by sprocket chain connections in a shallow trench beneath the floor, either spindle being turned by a socket wrench inserted through a hole in the trench cover plate. The tops of the flues are of hollow fire-brick carried on 4-in. T-bars, and over this is laid a course of fire-brick surmounted by the concrete of the trenches and floor.

The smoke stack is a 200-ft. radial brick chimney with fire-brick lining and presented considerable difficulty in its construction on account of the light and treacherous character of the soil. In the excavation which was made for driving the piles, quicksand was encountered which rendered the use of a cofferdam necessary. Although this was of the most substantial construction, 35 ft. square, it was threatened with destruction by the shifting of the banks. The excavation was carried 3 ft. below the lowest water recorded and then 121 12-in. wooden piles were driven to refusal on 3-ft. centers. The carrying capacities of the piles alone, calculated from the average penetration just prior to refusal, was much greater than that necessary to support the entire weight of the stack. The tops of the piles were then capped with concrete which filled the bottom of the cofferdam to a depth of 6 ft. Above this the section of the footing was decreased by steps until at a point 10 ft. below the boiler room floor the foundation was finished with a surface 25 ft. square. At this point the connection from the main smoke flue from the boiler room enters the stack and the brickwork of the stack proper was begun. The base of the stack is 19 ft. square with a 12-ft. flue to a height of 14 ft. above the boiler room floor, where the section changes to circular, 17 ft. in diameter. The exterior diameter decreases to 11 ft. 3 in. at the cap, the flue opening at the top being 10 ft. The chimney was built by the Alphons Custodis Chimney Construction Co.



Arrangement of Feed Water Heaters, Cisterns and Feed Piping.

Boiler Room Auxiliaries.—The heating of the boiler feed supply is accomplished by exhaust steam from the auxiliaries in two 5,000-h.-p. heaters in the side bay of the turbine room. They are Worthington heaters of the closed type, and large enough to provide for the addition of a second 1,500-kw. unit. There are two feed pumps capable of supplying the boiler equipment for the entire rated capacity of the station. They are 10x6x10-in. Epping-Carpenter duplex pumps of outside end packed construction with pot valves. The delivery piping to the boilers consists of two lines, connected to both pumps and heaters and to every boiler, one of 4-in. and the other of 2½-in. pipe. The 4-in. line will be used under ordinary service conditions, the smaller line being retained for testing purposes and reserve in case the larger line is cut out. The individual boiler connections are of 2½-in. pipe with connections to either line and have the usual arrangement of double valves with check valve between them for ease of access to the latter, while the boilers are in service.

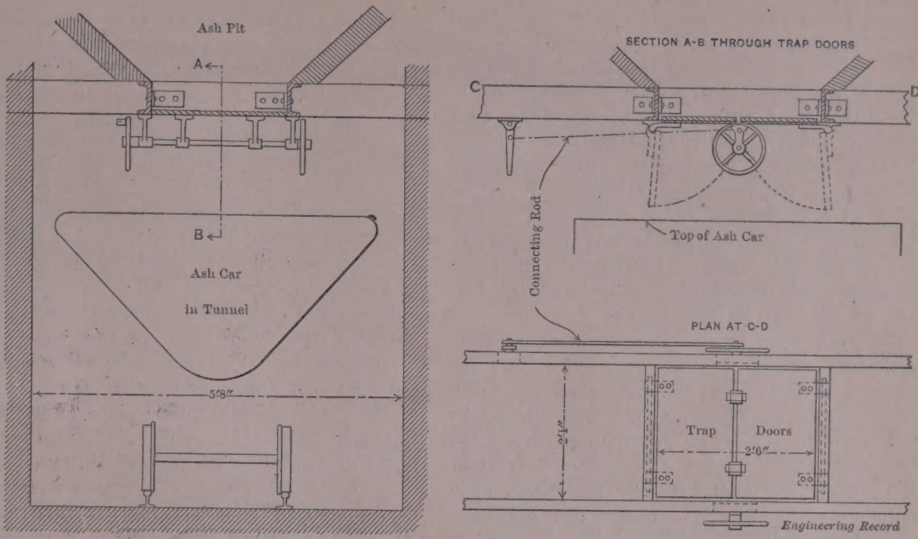
The water supply for the station is drawn from two 3-in. driven wells at the rear of the boiler house adjacent to the stack. It is forced by an electrically-driven 4x5-in. triplex pump into a 4-in. main leading to a 50,000-gal. storage tank on the neighboring hill. The pump is driven by a 5-h.-p. General Electric induction motor. The tank on the hill is nearly 80 ft. above the service mains in the boiler room. The water is of excellent quality for boiler purposes. The main boiler feed supply is stored in two 2,000-gal. hot-water cisterns in the boiler room into which water from the condensers is delivered directly, the make-up being added automatically by a float valve on the water service connection to the cisterns. The 6-in. suction pipes are in duplicate from the cisterns to either pump. The 6-in. suction lines enter the cisterns through stuffing box sleeves about 3 ft. beneath the normal water level. These boxes consist of pipe flanges and a short section of 6-in. pipe, bedded in the concrete of the cistern wall; on the water side of the wall, the sleeve was screwed into the cast-iron flange in the usual manner, while the flange on the outside of the wall was bored out to slip loosely over the sleeve so as to form a gland for a stuffing box in which the bolts projecting through the wall from the flange on the water side serve to close the joint by forcing the flange inwards. A ¾-in. recess was left around the outer edge of the pipe sleeve, which was packed with oakum and compressed by the novel gland. The bolts that served to tighten the gland were also used to attach the adjacent length of pipe to the pump connections.

The boiler blow-off system consists of a 4-in. header in trenches at the rear of the boiler settings, which has two 3-in. connections to each boiler. Each boiler outlet has double valves, one a gate valve and the other a plug boiler cock with asbestos packing. The 4-in. main discharges through a small tunnel built out from the boiler house beneath the surface between the stack and the turbine building walls to the shore line; at the outer end of this tunnel the blow-off main ends in an open discharge. This tunnel is connected through trenches in the boiler room with a series of leakage and gutter drains and also serves to drain the gutter outside the boiler house adjacent to the highway.

Turbines.—The steam turbine equipment of the station at present consists of the two 400-kw. Westinghouse-Parsons turbo-generators, removed from the station at Roslyn, and a new 1,500-kw. Curtis unit, with mechanically-operated governing mechanism, there being space left in the turbine room for an additional 1,500-kw. unit. The 400-kw. units run at 3,600 r.p.m. and the 1,500-kw. turbine at 900 r.p.m. and all operate with superheated steam. The latter is supplied through 5-in. lines from the 12-in. main superheated steam header to the two small units, and a 10-in. connection to the 1,500-kw. machine. Each of these connections is connected with the 8-in. saturated steam header in the boiler room for purposes of reserve supply, which in case of accident to the superheated line would enable the turbine to be operated temporarily with saturated steam. The two steam headers are similarly connected in the boiler room so that the saturated header may be used to supply superheated steam temporarily if necessary. The superheated piping system was installed by Westinghouse, Church, Kerr & Co., while all other piping was erected by the Nassau Light & Power Co. The steam piping is all covered with Keasbey & Mattison magnesia sectional pipe covering, that on all superheated piping being 3 in. in thickness. Both the superheated and the saturated headers and all branches are equipped with drip connections which are drained by Vesuvius return steam traps.

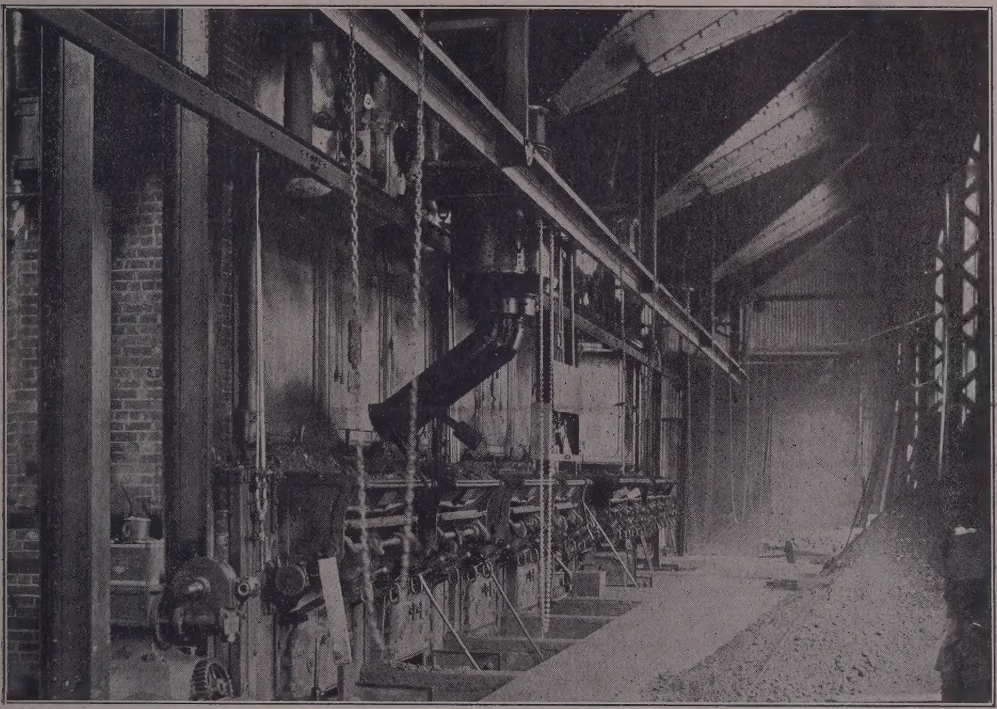
Steam Auxiliaries.—The turbines are all operated with individual surface condenser equipments, located underneath the operating galleries and in close proximity to the exhaust connections. The two 400-kw. turbines have 20-in. exhaust openings and 14-in. atmospheric exhaust lines with Kieley back-pressure valve exhaust heads. The Curtis turbine has an 18-in. atmospheric exhaust line and similar back pressure valve.

Worthington counter-flow surface condensers with air coolers are used. The condensers for the 400-kw. turbines have each 2,000 sq. ft. of surface while that for the 1,500-kw. unit has 6,000 sq. ft. of surface. The condensation is removed from the two smaller condensers by 1½-in. Worthington two-stage turbine pumps, each independently driven by a 5-h.-p. induction motor, while that from the larger condenser is removed by a 2½-in. pump operated by a 10-h.-p. motor. The arrangement of piping to the hot water cisterns is such that the condensed water from any turbine unit can be delivered to a separate cistern and there measured in making economy tests.



Details of Drop Bottom of Boiler Ash Pits.

For the large condenser a 10x16x18-in. Worthington dry vacuum pump is used, while the two 400-kw. units are served by a single 8x14x12-in. vacuum pump; these are of the straight-line flywheel type with a single air cylinder, in which poppet valves, mechanically-operated, are used. The large pump has an 8-in. vacuum connection to the condenser of the 1,500-kw. unit while the small pump has a 5-in. intake header with 4-in. branches to each of the smaller condensers. These two pumps are connected by a 5-in. cross line which permits either to operate on either condenser. Water coolers are provided in the vacuum lines to the condensers, through which the cooling water for the condenser proper is circulated before entering the latter. The air cooler for the large turbine has 180 sq. ft. of cooling surface while that for each of the smaller condensers has 92 sq. ft., the result of this arrangement being to reduce materially the work imposed upon the dry vacuum pumps.

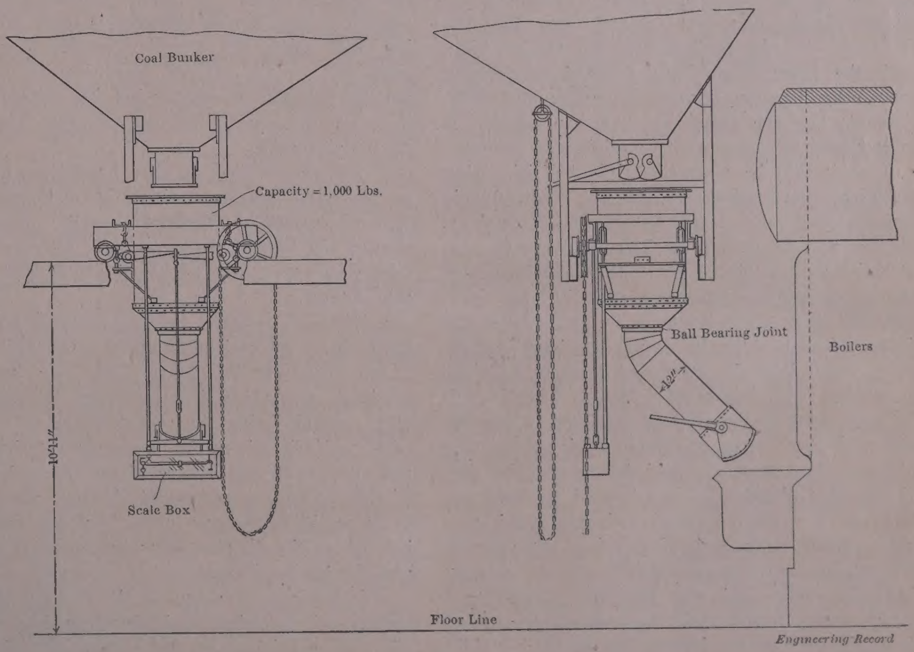


Boiler Room View Showing Coal-Weighing Chute

The circulation water supply to the condensers is furnished by two No. 14 Worthington volute centrifugal pumps located beneath the switchboard gallery with direct suction connections to the intake water tunnel. Each is driven by a 9x12 New York Safety vertical automatic steam engine and has 15-in. suction and delivery connections. The deliveries from the two pumps unite in a 20-in. header, from which the connections into the air coolers and their condensers are taken. The discharge connections consist of two 15-in. lines, one from the large condenser and the other from the two smaller units. Considerable reserve capacity has been provided in the intake and discharge tunnels, which were designed for a station capacity of 5,300 kw. The design is based on the use of 20 lb. of steam per kw-hour in the turbines while operating at 50 per cent. overload on above capacity, which at 70 volumes of water for the condensing duty, will require 11,130,000 lb. of water per kw.-hour. The cross-section of tunnel selected is approximately 24 sq. ft. in area, which will handle this volume of water with a current velocity of 2 ft. per second.

A hydraulic pressure system has been installed for use in connection with the step bearing of the Curtis turbine, consisting of two steam duplex pressure pumps which are fitted with automatic regulators, so adjusted that pressure will be continuously maintained upon the step bearing. These are each 7½x2x6-in. duplex pumps with outside end-packed water plungers, and have a capacity of 7½ gal. per minute at a pressure of 800 lb. No accumulator has been installed for this pressure system, the duplication of pumps being depended upon for continuity of operation; the latter is insured by the use of governors on each pump, one of which is set to operate its pump at a lower pressure than the other so that if the one operating normally should stop, when the pressure drops slightly the reserved pump will start.

There was also installed in connection with the Curtis turbine a special oiling system for the oiling



Details of the Traveling Coal-Weighing Chute.

of the two generator bearings of the unit. This consists of a 50-gal. elevated supply tank, a complete system of brass piping and a 50-gal. discharge tank in the lowest part of the turbine room to which the drips from the bearings are collected for settling. From the latter the clean oil is pumped to the elevator tank by either one of two 2x1¼x2¾ duplex steam oil pumps, a glass gauge in the upper tank, which is located at the wire tower gallery level, being visible from the turbine room floor so as to permit the supply to be gauged. The latter equipment was furnished together with the turbine by the General Electric Co.

Electrical Equipment.—The electric generating equipment consists of the two 400-kw. and the 1,500-kw. generators of the turbo-generator units. These are of the revolving-field, high-speed type and furnish two-phase alternating current at 2,200 volts and a frequency of 60 cycles. Excitation current is supplied to the generators by a motor generator set and a steam-driven generator in duplicate, each of which machines is of 35 kw. capacity, and delivers 125-volt direct current. An elaborate switching and control equipment is provided in the galleries for the control of the circuits. There are three distinct switchboards, one of three panels for the control of the generators, another of eight panels for the low-tension distribution circuits and a third of six panels for the high-tension circuits. All local distribution, embracing circuits of lengths up to about five miles, is operated at the generator voltage of 2,200 volts, while the long-distance circuits are stepped up to 6,600 volts for the transmissions and stepped down at sub-stations to 2,200 volts for local distribution. The entire switchboard equipment and the exciters are General Electric standard apparatus throughout, the oil switches being of the mechanically-operated type.

This plant was designed by Mr. C. O. Mailloux, consulting electrical engineer, New York, the details and the supervision of its construction being in charge of his assistant, Mr. Willis H. Heath. Since the early part of last summer it has been managed by the operating department of J. G. White & Co., New York, which is represented by Mr. K. B. Thornton, local manager.

The New Building which will be erected for The Engineering Record and other papers owned by the McGraw Publishing Co., has brought so many inquiries to this office concerning the structure that a few words seem necessary, although very little can be said at this time. The building will be on 39th St., between Seventh and Eighth Aves., on a plot 126.4 ft. long and 98.9 ft. deep. It will probably be ten stories high, with the lower four floors devoted to printing machinery, the top floor to an engraving establishment and the remaining floors to offices. It is proposed to construct it of reinforced concrete, and as it will be near the United Engineering Building, the Engineers' Club, the Pennsylvania terminal and other important centers, special attention will be paid to making the structure as atractive as possible. As it is the most important reinforced concrete building project in New York, and will have much influence in determining the future of such work, its design has been intrusted to Prof. Wm. H. Burr and Messrs. Radcliffe & Kelley, with whom Mr. W. S. Timmis will be associated as the leading specialist in the design and mechanical equipment of large printing offices. The structure will be erected by Mr. Frank B. Gilbreth. It is proposed to make the building a notable example of reinforced concrete construction and of printing office architecture, but until the specialists who are preparing the plans and the Building Department, which must approve them, have definitely reached a conclusion nothing further can be made public.

Rates for Electric Current in Chicago.

A report to the Gas, Oil and Electric Light Committee of the Chicago City Council, by B. J. Arnold and Wm. Carroll.

The purpose of this report is to show the results of an investigation into the business of the Chicago Edison Co. and of the Commonwealth Electric Co. This inquiry was made with the intention of getting information which would enable your committee to report to the city council a reasonable maximum rate for incandescent lighting that the above companies should justly charge. This report does not cover power rates for motors, special business such as sign lighting, arc lights for streets, or electric railway business.

Owing to the limited time given us by you for this investigation all published figures, information and data furnished by the lighting companies have been taken, as we are informed by the companies that their books are audited monthly by public chartered accountants. It would take months for us to properly audit the books and check the figures submitted. Full detailed and, so far as can now be seen, correct information in reply to all questions has been cheerfully given by the companies, much of which has been of a confidential character.

From the apparent differences of opinion between the attorneys representing the city and those representing the lighting companies regarding the right of the city to compel the companies to accept less than cost upon any portion of their business, the city contending for this position and the companies against it, it seems necessary to divide this report into two parts, as follows: First, what is a reasonable maximum rate on the assumption that the companies cannot be compelled to accept less than cost? Second, what is a reasonable rate on the assumption that the companies can be required to serve a portion of their customers at less than cost, provided the returns on the total lighting business are reasonably profitable?

Before entering into a detailed discussion of these divisions it may be well to call attention to the following facts.

1. The City of Chicago depends upon the Chicago Edison Co. and the Commonwealth Electric Co. for a large part of its commercial electric lighting and for all practical purposes these two companies are the same.

2. There is very little complaint as to the quality of service which these companies are rendering. The highest grade of engineering skill, the most improved equipment and the latest advances in the art of generating and distributing and using the electric current have been combined by the liberal investment of capital, and the result is an electric lighting system which is to be commended for the reliability and quality of its service.

3. The use of large modern generators in large concentrated power stations is decreasing the cost of producing electrical energy, but transmitting it longer distances and distributing it over wider territories offsets this saving to a certain extent.

4. When the electric lighting business was new there was a general adoption of a maximum rate of 20 cents per kw.-hour. This rate has been gradually reduced in different cities, the most notable example being the recent action of the city of New York, where the maximum rate has been put at 10 cents per kilowatt-hour in the borough of Manhattan, a congested district, and at 12 cents per kilowatt-hour in the borough of Brooklyn, where the distance of transmission is greater and the business more widely scattered.

5. In Chicago the use of the Wright demand system of metering and charging for electric lighting furnished by the Edison and Commonwealth companies is almost universal. With this system two meters are connected for each customer, one (the watt meter) to show the kilowatt-hours of electrical energy actually supplied during any month or other period, and the other (the maximum meter) to show the greatest demand made at any one time. Both meters are read monthly. The charge for current is made at the rate of 20 cents per kilowatt-hour for that amount of energy equal to a 30 hours' use of the capacity indicated by the maximum-demand meter, and at the rate of 10 cents per kilowatt-hour for all current in excess of this amount. The maximum charge is subject to a discount of 20 per cent. for the prompt payment of the bill, and the low rate charge is subject to varying discounts according to quantity used. No minimum is charged. The original installation of lamps and lamp renewals are furnished free.

The intention of this system of charging is to make good customers of all users, that is, as far as possible, to make each customer pay not only for the cost of actually producing his current but also to stand his equitable share of the fixed charges upon the investment which it has been necessary to make in order to get ready to serve him. The demand meter differentiates between "short-hour" users and "long-hour" users, and gives the benefit of the lower or secondary rates to a customer only after he has paid for sufficient current at the maximum rate to reimburse the company for the use of its capacity as indicated by the maximum meter.

The necessity of some such system of charging arises from the fact that electric companies must manufacture the most of their product only as required, and, therefore, cannot in fairness to themselves, or to the community, charge a flat rate similar to that of the gas companies who can manufacture gas at a uniform rate and store it in gasometers. Storage batteries are used by electric companies to accomplish a similar object, but the cost of batteries prohibits their use for any considerable amount of the load. There are a number of systems of charging in use in different cities, all of which have been adopted with the idea of dividing the charge for current into two parts, one varying with the fixed expenses on the entire system, and the other varying with the output of the generating plant. The system now in use in Chicago was adopted after a careful investigation and has been thoroughly introduced so that at present over 95 per cent. of the lighting customers of the two companies are served through the double meters.

It should be pointed out, however, that the movement to reduce the maximum rate and the system of charging provided by the Wright maximum meter are diametrically opposed. To reduce the maximum would ordinarily mean to equalize the schedule of rates, that is, if the maximum is reduced and the income remains the same, then the minimum must be correspondingly increased, the movement being toward a flat or uniform rate, and this is exactly what the advocates of the Wright demand system are trying to get away from.

The working out of the Wright demand system to its logical conclusion would mean that each customer would stand on his own feet and pay for the actual and equitable cost of his service plus a profit, and if this could be done the supply companies would be doing no part of their business at a loss, but this cannot be accomplished if a limit is put on the maximum charge.

On the other hand, if the maximum charge is reduced, the lighting companies will be forced to do a certain amount of their business at a loss, that is, the "short-hour" consumers—who are the ones most affected by the maximum rate

—will be getting their current at less than actual cost, and the loss must be made up by a reduction in income or by making higher than would otherwise be necessary the rate to the "long-hour" consumer.

Theoretically each customer should pay for his own service, and as the Wright demand system aims to accomplish this result, it is theoretically a step in the right direction. On the same theory, however, every merchant should charge proportionately more for the delivery of small purchases than for large ones—that is, if a pound of coffee or a yard of silk is delivered by itself a higher charge per pound or yard should be made than would be the case if this small purchase were to be delivered with a larger bill of goods. This policy would not be considered good business. As other merchants consider it to their interest to do a certain amount of their small business at a loss it is not surprising to find that public sentiment is in favor of reducing the maximum rate for lighting, even if the supply company must make up this loss by a slightly larger charge than would otherwise be made upon their larger sales.

The problem, therefore, resolves itself into the establishing of a fair balance. The desire of the lighting companies is to make each customer pay his own bills, and therefore, they wish to maintain a schedule with a high maximum and a low minimum. The sentiment of the public is apparently to reduce the maximum so as to give the greatest number of customers the benefit of a comparatively lower rate, even if this benefit is to be secured at a loss to the companies, or at the expense of the wholesale customers. The question, therefore, involves the rights of the "short-hour" customer, of the "long-hour" customer, of the wholesale customer, and of the producer, and should not be settled entirely in favor of any one and at the expense of the others.

As already indicated the discussion of the problem has been divided into two parts:

First.—What is a reasonable maximum rate on the assumption that the companies cannot be compelled to accept less than cost?

1. The maximum rate of the Edison and Commonwealth companies at the present time is 20 cents per kilowatt-hour, with 20 per cent. discount on the maximum part of the bill for prompt payment, leaving a net maximum rate of 16 cents per kilowatt-hour.

2. The 20 per cent. discount for prompt payment has been in force since July 1, when it was put into effect with very little publicity. This discount practically means the reduction of the maximum rate from 20 to 16 cents, or a reduction of 20 per cent. in the maximum rate has been made during the last year.

3. There are two ways to alter the present maximum rate:

a. By changing the maximum part of the rate to 15, to 14, to 13, to 12, to 11, or to 10 cents, as may be agreed, leaving the secondary part of the rate at its present amount, viz.: 10 cents. The reduction of the maximum rate in this way to 10 cents without changing the secondary rate would thus ultimately result in a "flat" rate which would treat all customers alike irrespective of the amount or character of their demands.

b. By changing the time during which the demand registered by the maximum meter must be used before the customer gets the benefit of the secondary or lower rate. At present this maximum demand (in kilowatts) is multiplied by 30 (hours) to get the kilowatt-hours which must be used at the maximum rate before the secondary rate is applied. This 30 hours might be reduced to 20 hours, to 15 hours, or to 10 hours, and the result would be to reduce the customer's bill. It should be borne in mind that the maximum-demand meter does not indicate the length of time during which this greatest demand continues. Whether or not this system works an injustice depends upon the character of the customer's load. For instance, in the case of a flat owner using his maximum number of lights for only two or three evenings in a month the practice of charging for 30 hours' use of this maximum capacity would be wrong, but to a restaurant keeper using his maximum capacity for four or five hours a day, or 150 hours per month instead of thirty, the practice of using the constant 30 is not unfavorable to the user.

4. There can be no doubt that with the maximum rate as at present some customers are served at a loss. In fact figures have been compiled by the companies showing that a large percentage of their customers are supplied at present at less than cost. In spite of this fact, however, the companies have evidently thought it best to reduce their maximum rates, which indicates their willingness to do a certain amount of business at a loss. If this is "reasonable," how far can it be carried?

5. No attempt has been made in this investigation to discuss at length the minute details of the method used by the companies in figuring their costs to their smaller customers. A very cursory examination of the subject will lead to the conclusion at once that some of the business is carried on at a loss. To discover and agree exactly just how many customers are now being served at a loss, and how many more would be included in the losing class by a reduction of the maximum rate to any lower rate, would require much more time than has been available for the present analysis. We are satisfied, however, that quite a number (perhaps 25 per cent.) of the customers are not producing a profit. A reduction in the maximum rate will naturally increase the number of customers in this class, which number is claimed by the companies to be at the present time over 10,000.

6. Although the number of customers getting served at a loss may appear large, the total amount of actual loss to the companies when measured in dollars compared to the total income from all lighting customers is small, for it is only those using a small amount of current that are supplied at a loss.

7. It is only by arbitrarily reducing the maximum rate in one of the ways indicated above that the "short hour" customers will get the benefit of advances made in the art. For instance, the actual cost for fuel used in producing the electric current of the companies under discussion is such a small proportion of the total cost of supplying a small or "short-hour" customer that if some method were discovered whereby the cost of fuel could be entirely eliminated, the investment remaining the same as at present, the reduction in the maximum rate, if the entire benefit were to be given to the customers, would only amount to ½ cent per kilowatt-hour. To a customer paying the 16-cent rate this reduction would not be material, while to a wholesale customer getting energy say at 4 cents per kilowatt-hour, a reduction of ½ cent per unit would produce a considerable saving.

8. Improvements are being made in the art of generating and distributing electrical energy which are gradually decreasing the cost. The volume of the electric lighting business in Chicago is increasing rapidly, and this increase is gradually decreasing the cost of each unit of current distributed. The larger sizes of the generating units now available make the cost of getting ready to serve each customer less each year. The use of batteries to insure reliability of service and the extension of the circuits into larger and more sparsely settled territory are offsets, however, to the general tendency toward a reduction in cost.

9. If the contention is made and maintained that the companies are not to be expected to do any business whatever at a loss then the present maximum rate cannot be reduced. If the question is how much of their business they can be expected to do at a loss, then the answer can only be scientifically determined by going more deeply into their affairs than has been done thus far in this discussion. It is only by taking a broad view of the entire business that a conclusion can be arrived at as to whether the maximum rates can be reasonably reduced.

Second.—What is a reasonable rate on the assumption that the companies can be required to serve a portion of their customers at less than cost, provided the returns on the total lighting business are reasonably profitable?

1. There are a large number of combinations of the maximum and minimum rates which can be made. As we understand the proposal of the companies it seems that they are willing to agree, under certain named conditions, to reduce their present rates of 16 and 10 cents to a maximum of 14 cents and a secondary of 9 cents for the next two years, with a further reduction to 12 cents for the maximum rate and 8 cents for the secondary for the last three years of the next five-year period.

2. In order to show the relative influence of these suggested rates upon the income of the companies as compared with other rates, including a flat rate of 10 cents per kilowatt-hour, the following table has been compiled:

Possible Changes in Rates in Cents per Kilowatt-Hour.	Relative Total Income at Various Rates.	Decrease in Total Income at Various Rates.
20 and 10	100.0%	None
16 and 10	92.8	7.2%
16 and 10—with 10 hrs. time limit. 14 and 10	89.2	10.8
14 and 9—Suggested by companies for 2 years. 12 and 10	85.8	14.2
14 and 8 12 and 9 10 and 10 flat rate	82.3	17.7
14 and 7 12 and 8—Suggested by companies for last 3 years.	78.8	21.2
12 and 6	71.6	28.4

3. The above table shows that:

a. The reduction in rates already in force and made voluntarily by the companies amounted to a reduction in their gross income from lighting of 7.2 per cent. This does not include the loss sustained by waiving their minimum charge, which was done at the same time.

b. The reduction of rates for the first two years to 14 and 9 cents, as suggested by the companies, means a further reduction of 7 per cent. from their original income, or a total reduction of 14.2 per cent.

c. The reduction to 12 and 8 cents as suggested by the companies, means a further reduction amounting to a total of 21.2 per cent. of their income.

d. This last rate of 12 and 8 cents is actually less than a flat rate of 10 cents per kilowatt-hour, on account of the fact that the amount sold at the secondary rate averages twice the amount sold at the primary rate, so that under these conditions a rate of 12 and 8 cents is the same as an average flat rate of 9⅓ cents.

e. A reduction of rates to 12 and 6 cents would mean a 28.4 per cent. decrease in an income based on a rate of 20 and 10.

f. Either of the combinations of rates (14 and 8) or (12 and 9) are an exact average of the two sets of rates proposed, that is (14 and 9) and (12 and 8).

4. To determine whether or not it would be

reasonable to ask the companies to do more at this time than they have indicated their willingness to do, a careful study and analysis has been made of the figures which they have submitted with the following results:

a. The full valuation of the properties and franchises as fixed by the Board of Equalization for taxation purposes is $25,707,000.

b. To make an inventory in order to get at the exact physical value of the properties, or to make an estimate of a replacement value would take more time than has been allowed for this investigation.

c. The sum total of the outstanding bonds and stocks does not exceed the published investment upon which interest and dividends are paid. That is, dividends are not paid upon stock which represents the value of the franchise. No bonds or stock have been recalled, however, to take care of depreciation.

d. Interest at the rate of 5 per cent. is paid on the bond issue and dividends at the rate of 8 per cent. annually are paid on the stock issued. The average annual charge for interest and dividends is 6.5 per cent. on the total par value of the bonds and stock.

e. The surplus earnings over and above interest charges are allowed to remain in the property to overcome the depreciation. The accumulated surplus and depreciation account amounts to about one-half of a theoretical depreciation account calculated on a basis of 6 per cent. per annum. In other words, it appears from the figures submitted that the companies have not been earning sufficient surplus to equal an annual average depreciation of 6 per cent. (Land is not included in the depreciation calculation.)

f. The lighting load is increasing at about the rate of 7,500,000 kilowatt-hours each year.

g. The operating costs are decreasing gradually as improvements are made and economies are introduced, but the income per kilowatt-hour has decreased in about the same proportion, which means that the large users and not the companies have been getting the larger proportion of the benefit of the increased economies due to the improvements.

h. The investment per kilowatt of connected load is now only about one-half as much as it was five years ago and it is mainly on account of this decrease in investment per unit of capacity that the price per unit of energy sold may be expected to decrease.

i. The percentage of current sold compared to the amount generated is decreasing instead of increasing. This is due to an increase in transmission and sub-station losses incidental to serving a larger territory.

j. The ratio of net earnings to gross earnings of the Chicago companies is slightly less than the average of a number of lighting companies in other large cities.

5. After a very careful study of the situation the conclusion reached is that the Edison and Commonwealth companies can afford to reduce their lighting rates. If there is no desire on the part of the city to embarrass these companies in their efforts to extend their lines and to render efficient and reliable service then their offer to reduce their rates to 14 cents for the maximum rate, and 9 cents for the secondary rate, for two years from the present time, and to 12 and 8 cents for the next following three years, may be considered reasonable and fair.

A thorough investigation of the affairs of the companies might show that these companies could afford to reduce their rates to 10 and 5 cents (equivalent to a flat rate of 6⅔ cents), but from all figures which have been submitted this rate at the present time would be a hardship and would probably seriously embarrass the companies, but it is reasonable to expect that the companies can afford to and probably will eventually reach this latter rate.

Speed of Vessels in Shallow Water.

The speed of vessels in shallow water is a subject that is now an important one on account of the controversy over the design of the Panama Canal. As there is much misapprehension concerning it, it may be well to note that the first important investigations were made by Capt. A. Rasmussen, of the Danish navy, who described his experiments with a torpedo boat in an article in "Engineering" of Sept. 7, 1894. He found that at half power his boat made 5¼ knots less speed in 15 ft. of water than in 48 ft., but at full power the speed was 1¼ knots greater in 15 than in 48 ft. depth. These results were confirmed a year later by Col. Guiseppe Rota, whose paper describing his experiments was published in the "Transactions" of the Institution of Naval Architects. These and later results obtained by Capt. Rasmussen, were so important to designers of shallow draft boats that they received careful attention and Sir John Thornycroft made experiments with a steamer drawing 10 in. of water in the shallow stretches of the Thames. He found that at full power the boat made better speed when running over a mud flat with only a few inches of water under her bottom than in the deeper channels. These and many other experiments are reviewed by Mr. Sydney W. Barnaby in the Watt Anniversary lecture, delivered on Jan. 19 of this year. The importance of the relation of depth of water to speed is very great, owing to custom of rating war vessels by speed trials over measured courses; if these courses are not in deep water the results of the trial runs at different powers are decidedly misleading. Mr. Barnaby calculates that a 780-ton, 33-knot destroyer would do best in shallow water when the depth is about 32 ft. and that in deep water the resistance would be normal at about 150 ft. A vessel of similar form but larger and capable of 36 knots would probably do best in shallow water of 36 ft. depth, while about 170 ft. depth would be required for normal deep-water speed. Attention is called to this important aspect of shallow water navigation, because it has been very largely overlooked in discussions of canal questions. The data on the subject are quite voluminous and surprisingly concordant.

Massachusetts State Highways.

The annual report of the Massachusetts Highway Commission for 1905 contains the interesting statement that the regular county hearings, provided for in the statutes, are becoming obsolete. The intention of the law was that methods of road construction should be discussed at these gatherings, and in the early years of the work much good resulted from interchanges of experience. The hearings were thus beneficial to both the Commission and the town officers, but they have gradually developed into meetings where a claim is made by some particular town for some particular road. As the Commission is familiar through long experience with most of the roads in the Commonwealth, it believes such hearings should be held at its headquarters, and therefore recommends repealing the requirement for an annual meeting in each county. The significance of this recommendation is the proof it affords of the general knowledge in Massachusetts of good highway construction.

No material change in the method of building roads has been made during the past year, and no failure of well-laid telford foundations or V-shaped drains has occurred. Experiments are being continued with various surfacing materials and methods. A gravel road which was built in 1901 was surfaced in 1905 with trap rock. The result is very satisfactory, and the road completed in this manner has cost less than it would had the broken stone been spread on the loose gravel in 1901. This saving is due to the reduced quantity of broken stone required, when it is laid on a firm sub-grade. Although the trap rock cost $2.08 a ton, the cost per square yard was only 42½ cents on this account.

The Commission reports that the continuous repair of the road surface and waterways, together with resurfacing when the surfacing material is worn through, is the only way to insure a permanently good road. An analysis of the maintenance charges on State roads shows that the cost in 61 towns was less than $50 per mile, in 60 towns from $50 to $100, and in 109 towns in excess of $100. The average cost was $111.56 per mile.

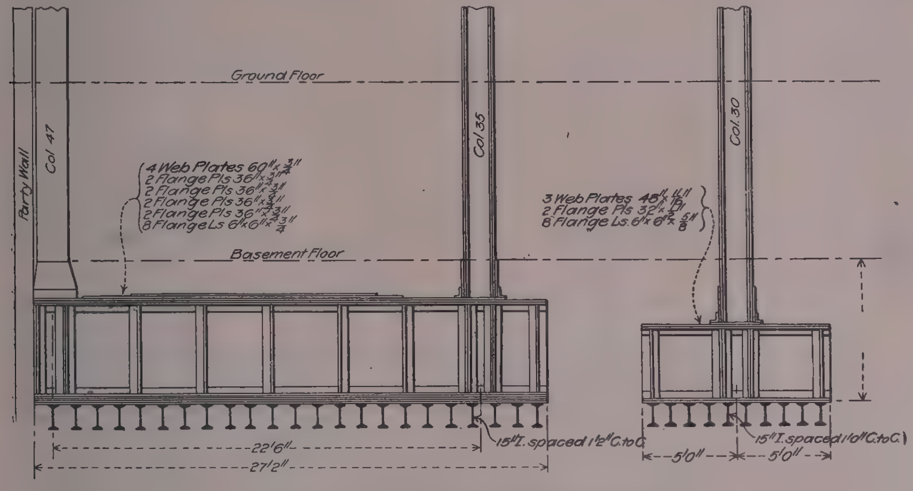
Considerable experience has been gained in the last two years in tree planting along the State roads, nearly 8,000 trees having been set out at an approximate cost of $10,000. It is well known that a small tree, properly nourished, if transplanted, will outstrip in growth and health a tree that, at the time of transplanting, was much larger; and in answer to the criticism of the small dimensions of the trees planted by the Commission, it should be said that the size determined on has been governed by what has appeared the best practice, without particular relation to the original cost of the tree. A careful inspection of each tree purchased has been made by the forester employed by the Commission, and those individually defective have been thrown out. Greater care has been exercised in the preparation of the ground for the reception of the trees, for it was found that the extraordinary drought of last spring killed many trees, a part of which might well have been saved had such a contingency been anticipated.

It has been considered advisable to place all trees received from the nurserymen in the nursery established by the Commission, so that they may get the added development of root fibres that tends to insure their future growth and strength. This makes two transplantings before the tree reaches its final location. The final setting should be made in most cases in the autumn. The cost of trees, transplanting, preparation of ground and final planting has been $1.01 per tree, as against $1.14 in 1904.

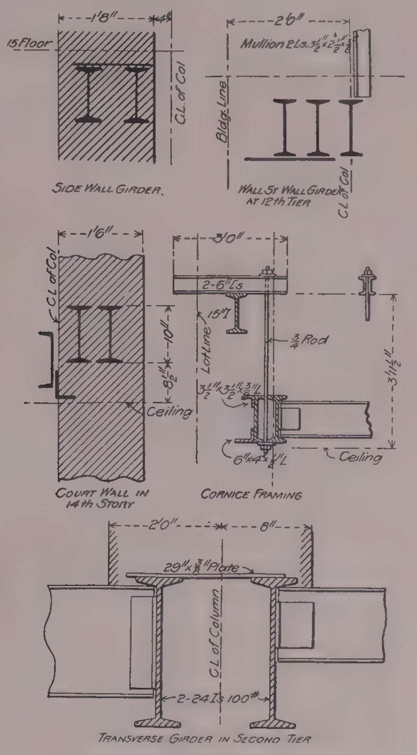
The Cotton Mills of the country have long regarded the New England Cotton Manufacturers' Association as its representative organization. This fact is well recognized in the industry, but is not appreciated by the public, so it is proposed to change its name to the National Association of Cotton Manufacturers. This is a desirable change, although the older members, who have witnessed the development of the industry from a strictly New England origin to one of wide distribution, may be pardoned for feeling regret that the name of a society which has stood for progress in every branch of the cotton manufacture will become obsolete. Few trade organizations have been conducted on more progressive lines than the New England Association, and while its meetings have been open to the reasonable presentation of manufacturers' claims for new apparatus, they have mainly been devoted to the discussion by cotton mill managers and engineers of the trade problems that have been interesting them. The society is one in which membership is a privilege and its nationalization in name is a step which should be taken to maintain its distinguished rank among other trade organizations.

Structural Steel Work in a New York Office Building.

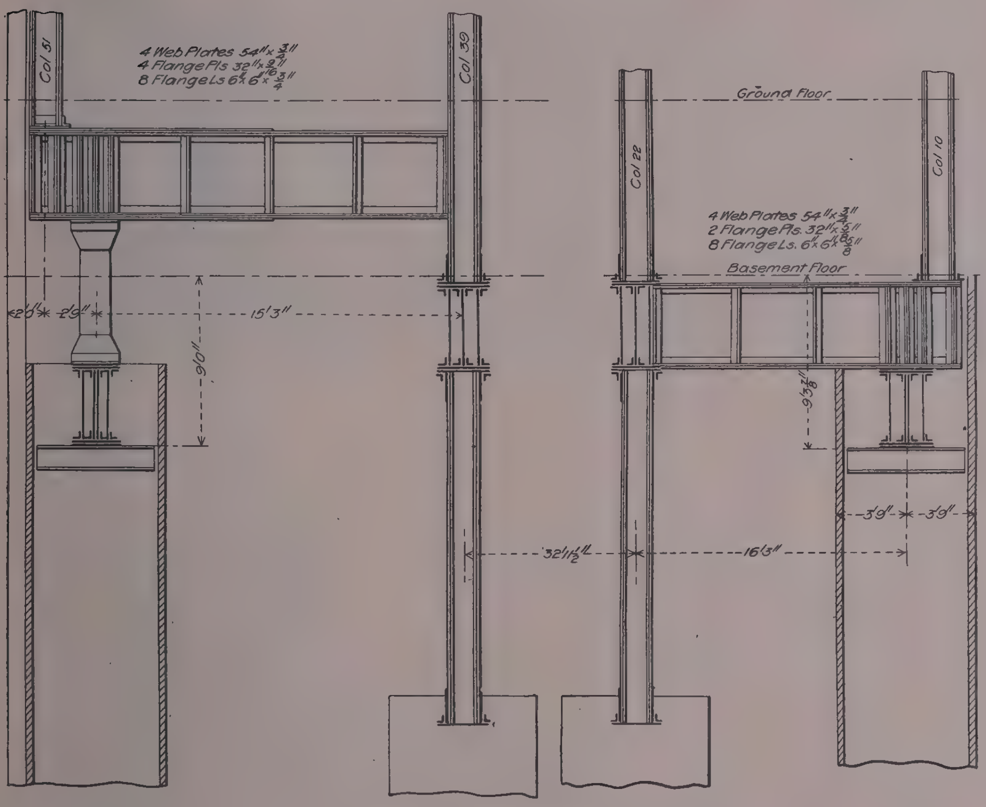
The new 192x75-ft. office building, at 60 Wall St., New York, is one of the tallest of steel-cage structures, having an extreme height of about 350 ft. above the pavement. It is carried up everywhere to a height of thirteen stories and attic, or about 202 ft. from curb to the surface of the roof. At the Pine St. end a length of 67 ft. is carried up for the full width twelve stories more, and is surmounted by an attic and penthouse which, together with the basement, subbasement, and mezzanine story between the second and third floors, make a total of twenty-nine floors. The lowest floor is of concrete, resting on the earth of the cellar excavation, and there are therefore twenty-eight tiers of steel beams exclusive of the roof framing of the pent-house.



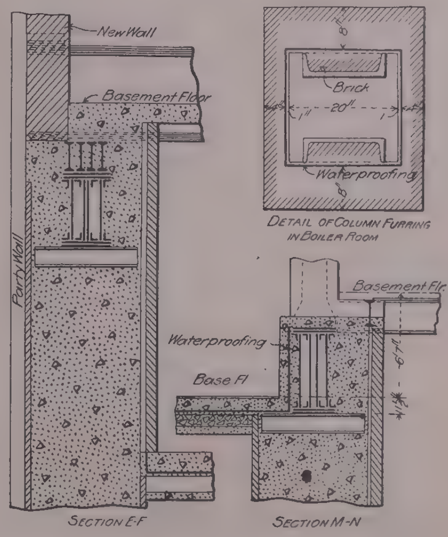
Foundation Cantilever and Distributing Girders.



Wall Supports and Cornice.



Elevated Cantilever Girders.



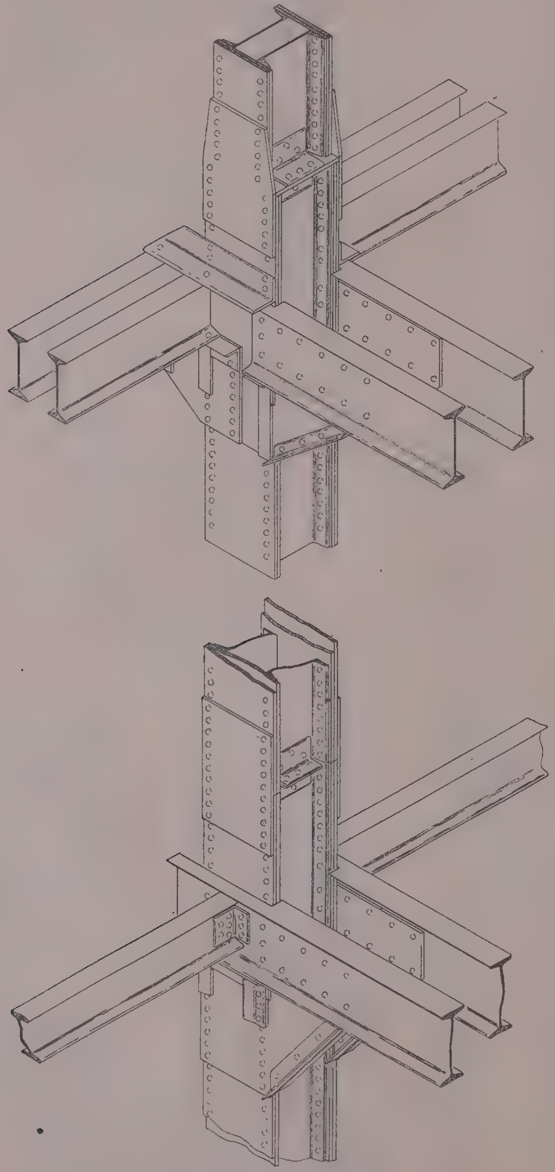
Distributing Girders and Grillages for Wall Columns.

At the Wall St. end, the basement is carried 18 ft. below the ground floor and there is no subbasement. At the opposite end, the basement is only 9 ft. below the ground floor, and there is a subbasement floor 21 ft. 8 in. below it. The heights of the upper stories from floor to floor are 16 ft. for the first story, 26½ ft. for the second, 18½ ft. for the third and 12 ft. for the succeeding stories up to twenty-fourth which is 12 ft. 9 in. and the twenty-fifth which is 12 ft. 5 in. in the clear. The attic above the thirteenth story is 9½ ft. and that above the twenty-fifth story is 8 ft. in height.

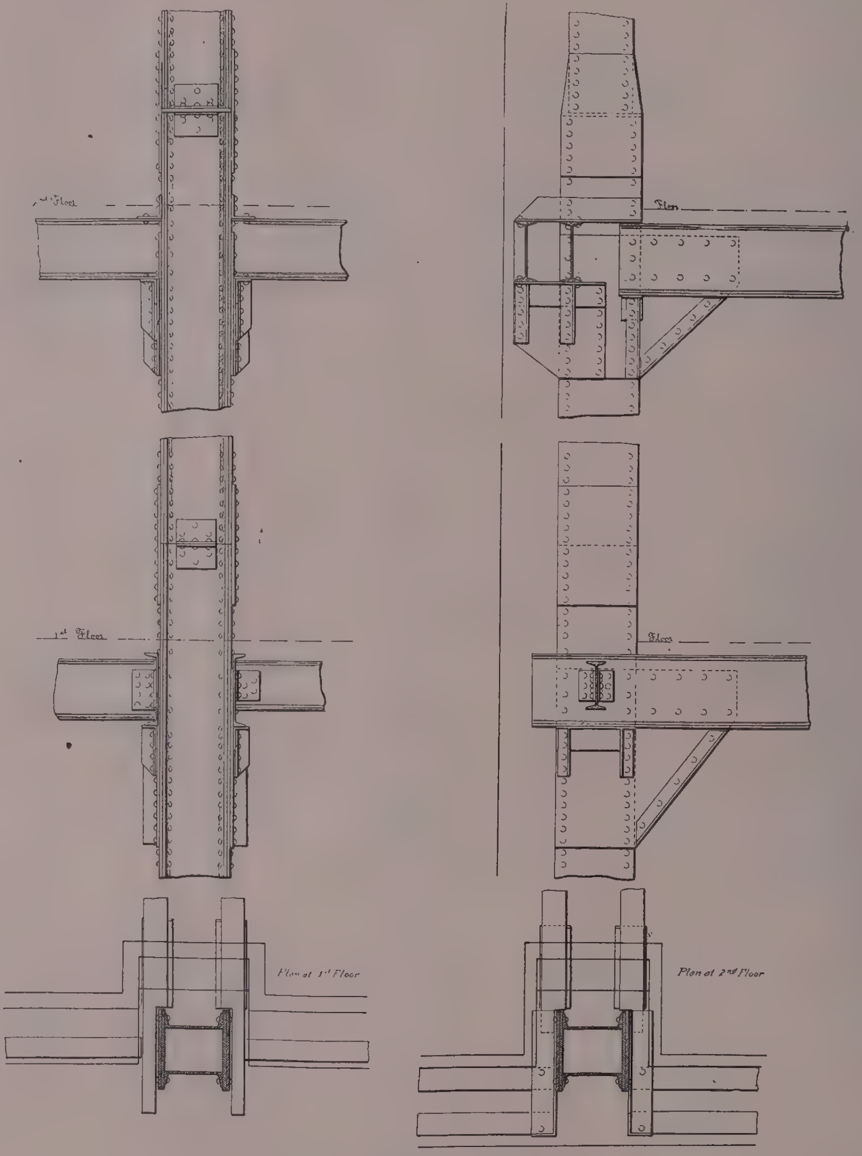
At the site of the building the soil is of fine sand with occasional pockets of quicksand and beds of gravel overlaying, at a depth of about 36 ft. below the curb, a stratum of hardpan from 1½ to 4 ft. thick, below which is solid rock. The ground-water line is 10½ ft. below the curb. Owing to the great weights to be carried, the problem of foundations was a serious one and was solved by the use of pneumatic caisson piers carried down to solid rock and designed for a pressure of 13 tons per square foot of bearing surfaces.

The piers are of two classes, cylindrical ones for the interior columns and some of the wall columns, and rectangular ones for the other wall columns. Most of the piers carry a single column each, but some of them are arranged for two columns. In all cases the column loads are distributed over the full areas of the tops of the piers by grillages made of I-beams from 10 to 15 in. deep. The columns are seated either on the centers of gravity of the grillages or are symmetrically arranged in pairs so that their resultant coincides with the center of gravity. The bases of the columns are only slightly extended and their loads are distributed equally over all of the grillage beams by means of girders at right angles to the latter. For the lighter columns these are three or four transverse I-beams, and for the heavier ones and those not in the center lines of the piers they are triple-web plate girders.

Where it is impossible to extend the grillages equally on both sides of the column centers, the girders act as cantilevers, allowing the columns to be set beyond the pier centers in the usual manner. There are several different types of arrangement for the column girders and grillages, as indicated in the accompanying elevations. The rectangular wall piers are carried up nearly to the basement floor level and are made practically continuous so as to serve as retaining walls for the excavation. Their grillages are, therefore, at a higher level than those of the interior column piers, and where it is necessary for the distributing girders to engage an exterior and an interior pier they are sometimes made as shown for column 22, where part of the weight is carried on each pier. In other cases, where wall columns are located beyond the centers of the wall piers, the cantilever girders may be seated directly on the distributing girders for the wall pier grillages, as shown for column 10, or they may be supported from the latter by the interposition of a short column, as shown for column 51. The opposite ends of the cantilevered girders have web connections to either an interior column, as shown for column 31, or to interior longitudinal girders which virtually form short sections interpolated between successive stories of an interior column, as shown for column 22.



Column Splice and Kneebrace



Front and Side Elevations of Wall Columns.

The interior columns are generally seated on the centers of distributing girders as shown for column No. 30. In some cases at the Wall St. end of the building, the same pier serves for interior and wall columns, and its wide grillage is crossed by a single distributing girder, which, although it does not overhang the grillage, is nevertheless a cantilever which receives the wall column load at one extremity and the interior column near the other end, with the moments so balanced that the center of the pressure is at the center of the girder, thus symmetrically loading the grillage beams. The girder is thus considered to be subjected to concentrated loads at and near the ends which are opposed by uniformly distributed loads in the opposite direction over its whole length, the girder being proportioned for a deflection so slight that all of the grillage beams will receive practically equal loads.

Wall column 48 is carried on a cantilever girder which has its fulcrum over the wall pier at a level somewhat above the top flanges of the distributing girder there. In order to provide a connection between it and the girder, a number of 15-in. I-beams parallel with the girder webs are inserted between the two girders as shown in cross-section E-F. This section also shows the construction of the sub-basement floor and inner furring wall. In all cases the distributing girders have the wall piers together with their grillage beams entirely enclosed with the concrete, which is carried up to form the top of the pier a few inches above the base plate of the wall column. The sub-basement is separated from the low basement floor by a transverse retaining wall formed by the upper parts of the long rectangular piers set continuously end to end across the building. These piers receive the grillages, distributing beams and basement floor connections as indicated in section M-N.

At the Wall St. end of the building the basement wall retains the earth excavation about 16 ft. high and is made of concrete 2 ft. thick at the top and 4½ ft. thick at the base, with a vertical outside face and a battered inside face. It is provided with waterproofing of tar, felt and hot asphalt against the inner face of the wall, protected by an 8-in. surface of brick. This waterproofing is continuous around the toe of the wall and across the cellar floor, where it is applied to a thin layer of concrete extending over a 10-in. fill of broken stone below which there is 5 in. more of concrete which, together with nearly a foot of concrete over the waterproofing, gives the floor a total thickness of 26 in.

The superstructure is carried on 51 main columns from 14½ to 18½ ft. apart in longitudinal rows, four at the Wall St. end and five at the Pine St. end of the building, which are from about 16 to 19½ ft. apart. All have closed rectangular cross-sections of two 15-in. channels and two more cover plates and, except for some irregularities occasioned by the varying positions of the distributing and cantilever foundation girders, they are made in two-story lengths with joints just above floor level, spliced by four web and flange cover plates which are partly shop riveted. The base plates are extended to the full width of the distributing girders and are stiffened with wing plates riveted across the channel flanges.

The floors have tile panels proportioned for 165 lb. per square foot total load except in the roof, first floor and attic, which have respectively 150, 300 and 100 lb.

The exterior walls are self-supporting on the masonry footings up to curb level, above that height they are carried in the usual manner by special girders attached to the wall columns, which do not receive any floorbeam loads. Above the basement floor the columns extend to the roof in vertical lines without offsets or variation in their locations and the 29 tiers of beams are of moderate dimensions and arranged in regular rectangular panels varied slightly for the stair and elevator shafts and the smokestack openings.

At the Wall St. end of the building, the basement floor has longitudinal 15-in. I-beams about 4 ft. apart, carried by box girders and by single and double lines of transverse 20-in. I-beams. At the Pine St. end, over the boiler room, the floor is made of longitudinal flat steel plates ⅜ in. thick 32 to 53 in. wide and from 13 to 16 ft. in length. The edges of these plates make butt joints with each other on all sides, and are spliced by cover plates riveted on the under side. They are supported on the top flanges of 12-in. transverse I-beams 2 ft. apart.

The second tier or first floor has a special construction for three panels on the west side of the building, where the floor is proportioned for a load of 800 lb. per square foot for vaults and is made of 20-in. 65-lb. longitudinal I-beams 2 ft. apart, supported by transverse girders each made of a pair of 24-in. 80-lb. or 100-lb. I-beams. The remainder of this tier, like most of the tiers above it, is made of 12-in. longitudinal beams and 15 and 18-in. transverse I-beams arranged singly or in pairs according to the location of the columns, most of them being in pairs. On the east side of the building four transverse girders at the Wall St. end have 24x⅜-in. web plates and four 4x6x¾-in. flange angles. In the third tier the exterior walls are carried on the sides of the building by girders composed of pairs of 15 or 18-in. I-beams with ⅜-in. top flange cover plates from 17 to 25 ft. in width. At the Pine St. and Wall St. ends of the building, the walls are carried on a girder 15 in. deep made of a channel and an I-beam set close together and having a 6x6x¾-in. outside shelf angle riveted to the web of the channel.

The mezzanine floor between the second and third tiers has a width of 10½ ft. at one end, where 7-in. transverse I-beams 4½ ft. apart are supported on longitudinal 12 and 15-in. I-beams. At the other end it has a width of 23 ft., and most of its floorbeams are longitudinal 10 and 12-in. I-beams carried by pairs of 15-in. transverse I-beams. At the fourth tier a light court 50 ft. long and about 47 ft. wide commences, making a wide opening in the center of the west side of the building. From this tier up, the side and end walls are generally carried by pairs of 12-in. I-beams with 17 and 25-in. cover plates on their top flanges. On the west side of the building some of them are web-connected to the cantilever ends of the transverse girders, which are continuous beyond the column centers. In other cases they are supported by brackets projecting beyond the faces of the columns.

The twelfth and thirteenth tiers support heavy masonry courses in the outer walls at the ends of the building, and carry them on triple lines of 12-in. I-beams which, at the Wall St. end, have a 16x½-in. bottom flange plate riveted to the outer pair of beams and projecting about 5 in. beyond the outer flanges. In the fifteenth tier, there is a set of special transverse girders in the center of the building, which are connected by 15-in. longitudinal I-beams about 2½ ft. apart. On these I-beams are seated 9-in. transverse I-beams 2 ft. apart, which form a grillage for the pressure tanks installed there for the elevator system. The sixteenth tier of beams forms the roof of the attic of the Wall St. end of the building where it is made of 10-in. longitudinal I-beams carried by pairs of 15-in. transverse I-beams. At the Pine St. end it serves as an ordinary floor and has 9-in. longitudinal I-beams carried by pairs of 15-in. transverse I-beams and the columns are connected longitudinally by pairs of 12-in. 25-lb. channels.

The Wall St. roof is enclosed by a parapet with steel posts 7 ft. high made of a pair of 6-in. channels, knee-braced at the top by a pair of 5x3-in. angles. The 67x73-ft. upper tiers at the Pine St. end are made of 12-in. longitudinal beams and pairs of 15-in. transverse I-beams. At the twenty-seventh floor the cornice frame is made of pairs of 6-in. channels 3 ft. long, back to back, spaced about 2 ft. apart and fulcrumed on a 15-in. I-beam beyond which they project 20 in. to receive the terra-cotta cornice blocks. Their inner ends are anchored by vertical screw rods to the pair of 12-in. girders carrying the upper part of the wall. At this floor special provision is made for a 13x6½-ft. water storage tank, which is seated on four 10-in. distributing beams carried on seven 7-in. transverse beams resting on the longitudinal floor beams, which are increased to a depth of 15-in.

The twenty-eighth or roof tier has 9-in. longitudinal beams supported by pairs of 15-in. transverse channels, and carries a 20x36-ft. penthouse with its roof and walls framed of light beams, channels and angles. The main roofs are covered with tiles set in cement, and all of the interior steel work is enclosed by the fireproof floor construction or is protected by tile or plaster.

The building was designed and its construction was supervised by Clinton & Russell, architects, Col. J. H. Wells, engineer, and Mr. J. Dougan in charge of structural design. Mr. Chas. T. Wills was the general contractor, and the structural steelwork, weighing about 8,000,000 lb., was fabricated and erected by Milliken Bros.

End Panel Construction of a Skew Bridge.

Two 135-ft. riveted through truss spans of the single track bridge of the New York, Chicago & St. Louis R. R., over the Sandusky river at Fort Seneca, Ohio, are skewed at both ends to an angle of nearly 45 deg. The skew at the abutments has been provided for in such a manner as to avoid having some of the ties carried partly by the stringer and partly on the abutment or ballast, as sometimes occurs with skew spans. The trusses are 17 ft. apart on centers, and the track is supported by two lines of stringers 6½ ft. apart. The regular panels of the trusses are 22 ft. 3½ in. long, but in order to conform to the skew the end panel between the foot of the last vertical post and the shoe was made only 15 ft. 3⅝ in. long, corresponding to the amount of skew, and the panel adjacent to it was made of the same length in the truss making acute angles with the abutment or pier and of the ordinary length in the opposite truss. By this arrangement at each end of the span there is a short rectangular panel and a short triangular panel of floor system thus making all connections regular.

The end floorbeam reaching from *Lo* of one truss to *L1* of the other truss, carries the river ends of the end stringers, which are both about 15 ft. long and are seated at the shore ends on bearings in the same transverse line. One stringer is thus extended more than half its length beyond the face of the abutment, but all connections are square and the ties are uniformly supported. The feet of the inclined end posts are connected by a heavy diagonal strut. This arrangement was adopted at both abutments where the truss bearings are on roller shoes. The pier between them is parallel with the abutment faces and the lengths of panels and the diagonal struts connecting the feet of the end posts are the same as at the abutments, but as the spans have both fixed ends at this point the stringers could be made continuous from one span to the next and are therefore regular across the pier, except that their lengths are increased 3 ft., equal to the distance between the end pins of adjacent trusses. The bridge above described weighs 265,000 lb., which is an excess of 2,200 lb. over neighboring spans of the same length, which are square at both ends. The arrangement above described was adopted with considerable hesitation on account of the reluctance to vary the length of the truss panels. This objection proved to be groundless, since the appearance of the bridge is quite attractive and the construction is considered entirely satisfactory.

The bridge was designed and its construction supervised under the direction of Mr. E. E. Hart, chief engineer, and Mr. Albert J. Himes, bridge engineer for the railroad company, and was built and erected by the King Bridge Co.

Two 135-Ft. Spans over Sandusky River at Fort Seneca, Ohio.

PADDY HUSKS are used as a fuel in the interesting power station of the electric railway at Bangkok, Siam. The fuel is brought down the river from the rice fields in flat-bottomed boats to the power station, and unloaded directly into the boiler room by an elevator and belt conveyor, built by the Link-Belt Engineering Co., operated by several direct-current, 500-volt General Electric motors. The station has recently had its capacity increased by a 500-kw. Curtis steam turbine.

Curves for Reinforced Arches.

By Daniel B. Luten, President, National Bridge Co.

The use of steel reinforcement in concrete arches permits of a light arch ring in which the middle third no longer controls the thickness. The curvature of the ring is consequently subject to fewer restrictions, since live load moments may be offset by increased reinforcement, and the simple circular segments that formerly were used so extensively for masonry arches become too clumsy and inefficient for the reinforced type.

One of the neatest methods of designing a segmental circular arch under the former middle-third requirement is Alexander and Thomson's method as outlined in Howe's "Treatise on Arches." Where the load on the arch consists of dry earth filling resting vertically on the arch ring, the curve of equilibrium is the transformed catenary, which, however, is at a disadvantage in that it is a difficult curve to determine and one that nine engineers out of ten would seek to avoid. The Alexander and Thomson's method succeeds in establishing the limits of the middle third that contains the transformed catenary without attempting to determine that curve itself. It develops into the comparatively simple problem of drawing circles of such radii that the transformed catenary will lie within the middle third of the resulting ring. The idea is shown outlined in a rough way in Fig. 1.

If now the middle third of this ring could have been made to conform more closely to the transformed catenary, at the same time employing simple curves, it is evident that there would be great economy of material; for the middle third could then be reduced to a minimum and the thickness of arch ring be designed to resist the direct thrust.

Mr. Emile Low has used an arch ring consisting of an ellipse for the inner curve and a circle for the outer curve, and recommends that form for earth-covered arches, as shown in Fig. 2. (The ellipse is readily determined by drawing two concentric circles on the major and minor axes of the ellipse as diameters, and from the points where any common radius cuts the two circles, projecting lines parallel to the axes to their intersection, which will be a point of the ellipse.) For flat arches this combination results in considerable economy over the segmental circular arch, but it is too flat at the crown and too high at the haunches for an extremely light ring; it has been found that nearly all arches with elliptical intrados and thin arch rings will show slight cracks at the intrados crown.

A circular segment, on the contrary, will usually show cracks at the under surface at the haunches and will break away from the spandrels above the springings, showing that this curve is too flat at the haunches and too sharply curved at the crown for the earth loading. Evidently, then, some compromise between the ellipse and the circular segment should give better results for equilibrium.

In Fig. 3 is shown an arch in which the inner curve is a mean between the ellipse and the segment of a circle having the same rise and span, and the outer curve is a circle. In this figure the ellipse *abc* is the same curve as the inner curve of Fig. 2; the circular segment *adc* passes through the crown and springing of the ellipse. The inner curve of the arch is then determined as a mean of these two curves by bisecting the vertical distances between. In order to facilitate laying it out, the curve is approximated by arcs of circles determined by trial after a sufficient number of points of the curve have been plotted.

The outer curve is a circle having its center on the center line of the arch and a radius equal to the radius of the intrados at the crown, plus two and one-half times the crown thickness. This relation between the radii of inner and outer curves results in an arch ring of a thickness varying approximately as the secant of its angle of inclination.

Such an arch will be found to be in almost exact equilibrium under earth loading, and is believed to be a very close approximation to a linear arch for any loading of earth fill whose depth at the crown does not exceed two or three times the crown thickness. Where the fill does exceed this amount, it will nearly always occur in heavy fills where the semicircle is feasible and the most efficient curve, and for this case all the above solutions give similar results.

A concentrated load applied at the crown of such an arch as that of Fig. 3 will require reinforcement along the inner surface at the crown and along the outer surface at the haunches. By using one series of reinforcing members for both these regions and alternating the points of their crossing the arch ribs, the one system of rods can be made to reinforce the arch against all the stresses. By distributing the points of crossing so that the rods will cross at the middle and thirds of the half arch, this reinforcement will provide also for all possible concentrations of load on the arch.

This method of design and reinforcement, using smooth steel rods, has been applied in numerous arches up to spans of 100 ft. with invariable success. Sections are shown to scale in Figs. 4 and 6 of two bridges erected recently, and a view of the former is shown in Fig. 5. This arch is located on Cruft St., in Indianapolis, and is of 42 ft. 9 in. span on a skew of 45 deg., with a 20 ft. roadway. The bed of the stream is paved with concrete to render the bridge flood-

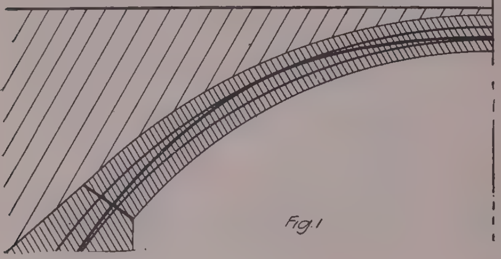
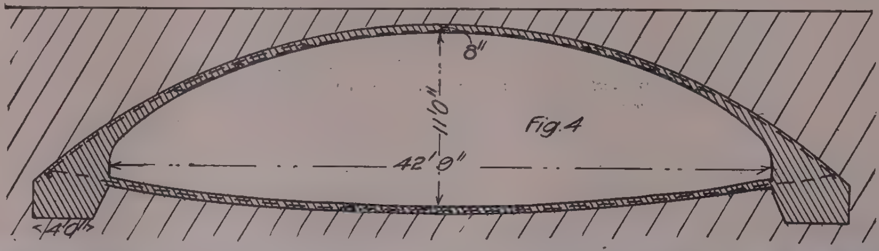


Fig. 1



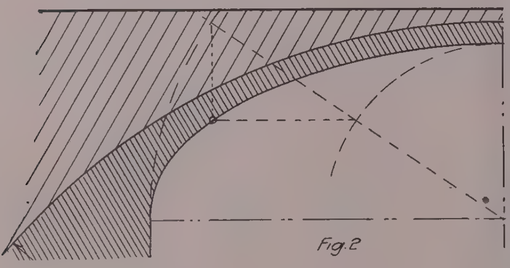
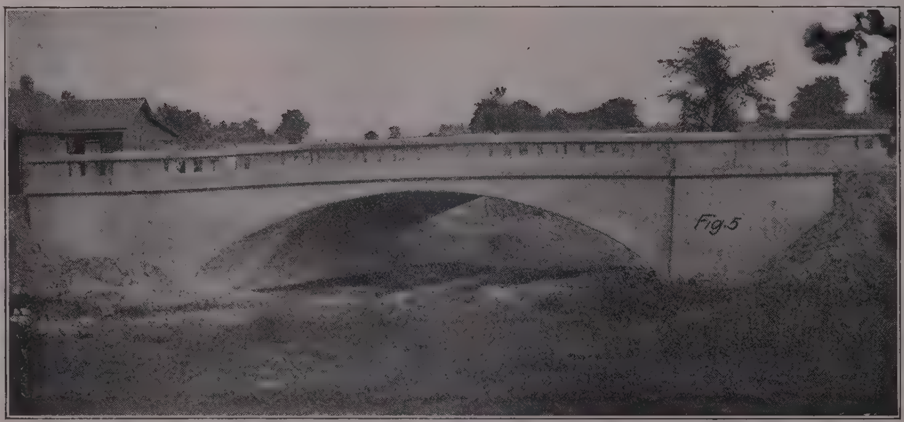
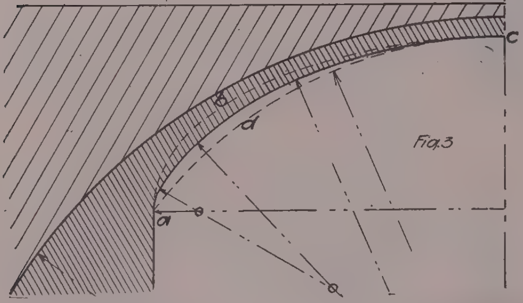
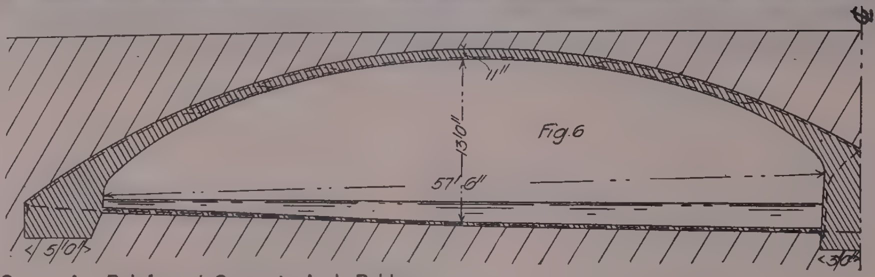


Fig. 2

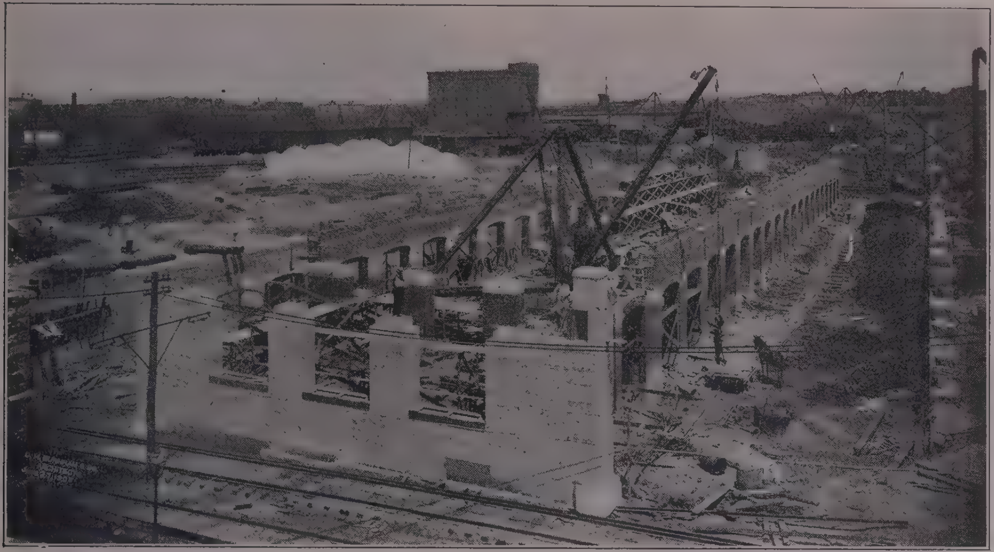






Examples of Curves for Reinforced Concrete Arch Bridges.

proof, and steel rods from abutment to abutment are embedded in this pavement to resist the thrust of the arch. The completed bridge contains 135 cu. yd. of concrete and 6,000 lb. of mild steel, and the contract price was $1,290.



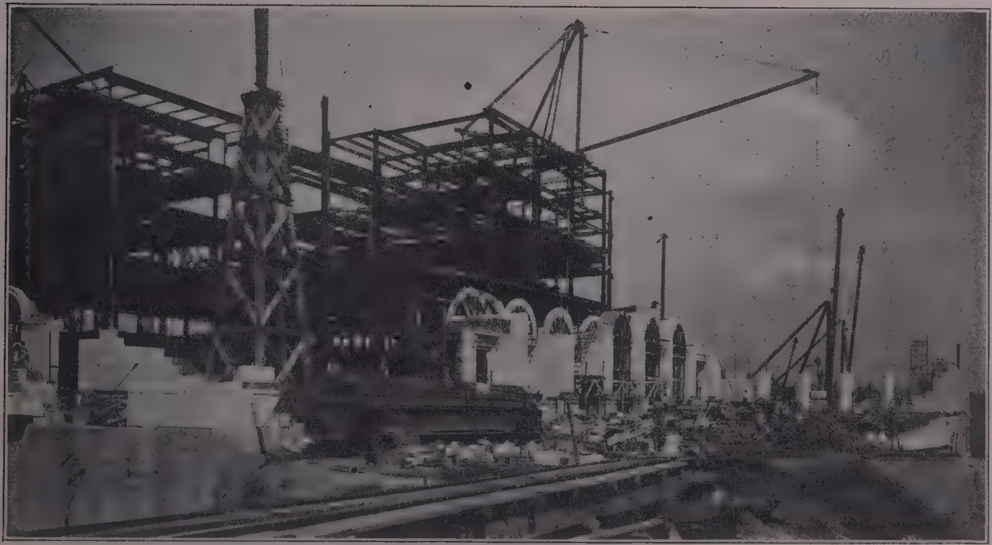
South End of Express Building, Basement Story, Washington Terminal

The section of Fig. 8 represents one span of a twin arch bridge at Franklin, Ind., each arch of 57 ft. 6 in. span, and 36 ft. roadway, paved with brick. The contract price for this bridge complete was $6,784. Both of these bridges were designed for concentrated loads of 20 tons and uniform loading of 200 lb. per square foot in addition to the dead weight of earth and concrete.

The former was erected by the National Bridge Co. of Indianapolis, who were also consulting engineers for the Franklin bridge, which was built by the National Concrete Co., also of Indianapolis.

Inclined Gas Retorts.

Inclined retorts of the Drory type are used in the new retort house of the Springfield Gas Light Co., in Springfield, Mass. Inclined benches are so unusual in this country that their adoption in this case deserves notice. There are nine retorts inclined 33° in each bench, and each retort is 20 ft. long. The results attained with the plant during the four months it has been in operation are very satisfactory. It is one of the few American inclined retort stations.



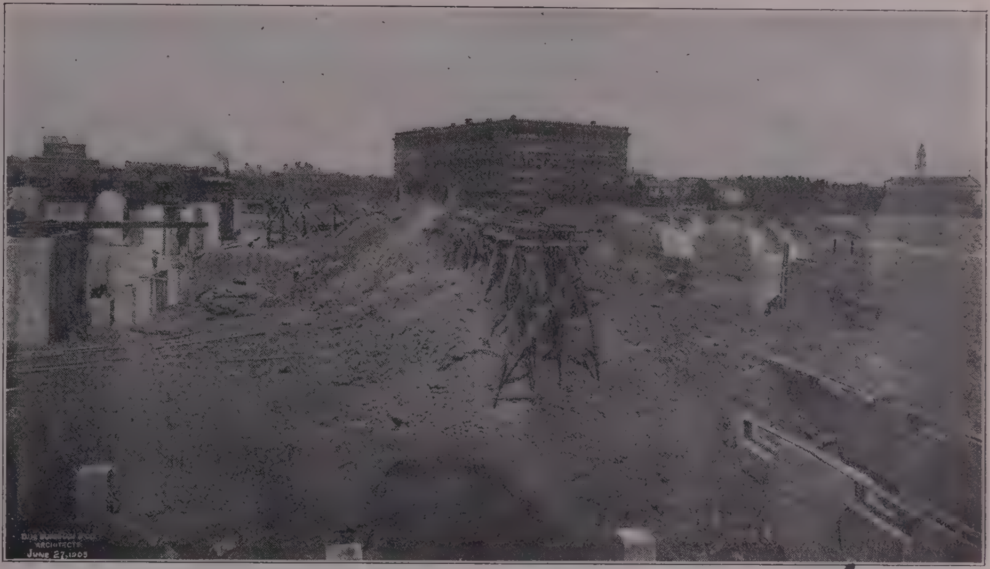
Granite and Steelwork of East Portico, Washington Terminal.

Progress on the Washington Terminal Improvements.

The construction of the union terminal for the Pennsylvania and Baltimore & Ohio Railroad Cos. at Washington has been progressing steadily and the present year will see the work reach a stage when the great changes this undertaking will make in the vicinity can be appreciated by all visitors to the capital. Until very recently the great masses of earth and building materials had little significance to the observer, but this condition is fast disappearing as the buildings rise, and the beauty of the plans of Messrs. Burnham & Co. and the railroad's engineers become apparent. The scope and nature of the improvements were described at length in this journal on Nov. 5, 1904, in an article by Mr. W. F. Strouse, assistant engineer of the Washington Terminal Co., organized to carry out the work.

The terminal site was originally a tract at the intersection of Massachusetts and Delaware Aves., having an average elevation of 22 ft. above mean tide. The floor of the station was fixed at an elevation of 58 ft., which required a great amount of filling in order to make a plaza in front of the headhouse. The latter is 620 ft. long and 220 ft. wide. Behind it is a roofed concourse 760 ft. long and 130 ft. wide, from which access will be had directly to the track platforms, which will be protected with umbrella shelters. The station is reached from the north on a long fill between heavy masonry retaining walls and from the south through a tunnel.

In preparing the foundation for the station a large amount of concrete was used, which was prepared by methods explained in detail in the article above referred to. Owing to the great height and small sectional area of some of the station piers, great care was necessary in depositing the filling material to avoid injury to the masonry. A description of this foundation work was printed in this journal on Aug. 6 and 13, 1904, and the accompanying view taken last summer during the filling of the concourse gives some idea of the heavy nature of the work. At the present time eight-tenths of the filling of the plaza and the streets leading to it has been completed, and considerable filling has been done on private property adjoining it. The greater portion of this material comes from the excavation for the coach yard, where about 2,250,000 cu. yd. of earth are being taken out in order to furnish track room for about 760 cars. This material is delivered to the plaza in trains of twelve 3-yd. side-dump cars hauled by dinkey locomotives weighing about 16 tons each. Each train makes about ten trips daily. The completion of the grading must be delayed until it is possible to remove the passenger tracks of the Baltimore & Ohio R. R. to a temporary position on the new level.



Condition of Filling at Concourse.

The character of the construction on the station proper is shown in the illustration of the east portion, which shows the condition there on Aug. 17. At the present time practically all the steel work for this part of the building is in place, the floors and fireproofing are practically completed, the granite outside facing is in place to a height of about fifty feet, and the enamel brick and terra cotta work is nearly finished. The rest of the building is not so far along. A good start has also been made on the erection of the arch trusses of the concourse roof. These have a span of 130 ft. and are assembled and riveted on the concourse floor. They are then erected complete by a tower traveler moving on the axis of the concourse and fitted with three derricks. Two derricks at the corners of the towers are used to raise the trusses while the third derrick, located on the top of the tower is used principally to guide the movement of the truss and to place the purlins. Attention is called to the derrick tower shown in the illustration of the East Portico. While this method of supporting a derrick is not exactly novel, it is rather unusual to use such a tower from the outset of the work in order to avoid the trouble of shifting and raising the derrick as the construction is carried up. The tower was used in this instance because of the dome construction at this point, which furnished no supports for derricks.

On the east and west side of the station tracks, just beyond the platforms are the express and power buildings. The former is a 60x420-ft. structure and a view of its condition on June 27 is reproduced as of interest in showing at the left of the picture a part of the site that will be filled to carry the tracks. This building fronts on H St., which will be carried under the tracks in a subway, of which details were given in this journal on Nov. 5, 1904. The construction of both buildings has been delayed by the strike of the steel erectors.

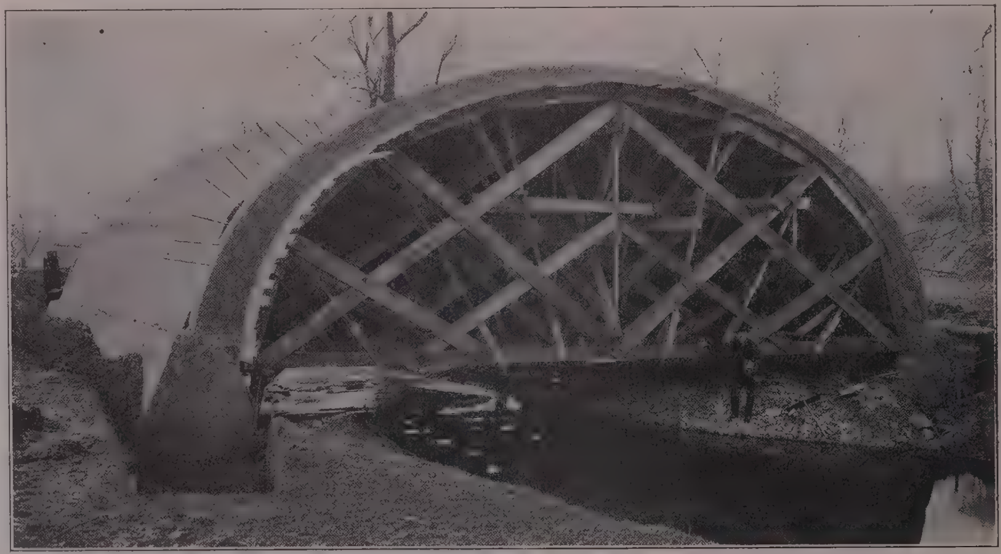
All the masonry on the long approach to the station from the north has been completed except gaps through which Baltimore & Ohio trains are moved. Practically all the heavy fill has been made, but owing to its depth and the settlement that will take place, no attempt will be made to bring the southern part of the work to grade before the coming summer. The northern part is practically finished, however, and track-laying has been started. All the bridges are erected, and the concrete flooring is done. Uniform satisfactory progress is being made on the tunnel approach to station from the south, but as the greater portion of this work must be done from the south end the progress is necessarily slow and to complete the work will probably require the balance of the year. About eight-tenths of the excavation of the coach yard has been completed and nine-tenths of the site of the engine and shop yard is ready for tracks and buildings.

The northern approach is being constructed by McMullen & McDermott and the Hoffman Engineering & Contracting Co. The terminal station is being erected by the Thompson-Starrett Co., while the southern approach tunnel is being driven by the New York Continental Jewell Filtration Co.

An Air-Lift Plant of unusual arrangement is employed at Des Plaines, Ill. The water is taken from three wells, piped under the Des Plaines River, and discharged into a cylindrical reservoir over which the mechanical plant is installed. The discharge from each well is into a pipe with its mouth at such an elevation that the water flows by gravity to the reservoir, a vent pipe being provided in the connection between the well and discharge pipe, so as to permit the escape of air. The entire installation was made by the Chicago Pneumatic Tool Co. and furnished during a test 270,000 gal. per day.

Special Falsework for a Concrete Bridge.

The Cobbs Creek bridge at Media, Pa., near Philadelphia, carries a double track electric railway and a highway about 19 ft. above the creek level by a single skew span 46 ft. 2 in. in the clear. The arch is a false ellipse of reinforced concrete. The intrados is a three-centered curve having a total rise of 17 ft. 5 in. from skewback to crown. The central part has a radius of 30 ft. 8 in., forming a segment subtended by a chord 30½ ft. long. At each end this segment is tangent to a segment of 15 ft. 4½-in. radius, which is continued beyond the springing line nearly to the intersection with the inclined plane of the footing. The extrados is of similar construction with center and end radii of 40 ft. and 16 ft. 10 in. respectively. The end segments do not, however, extend quite to the springing line but just above that point are tangent to reversed curves which diverge from the intrados so as to give the footings a width of 6 ft. 8 in. in a plane perpendicular to the direction of the resultant. The radial thickness of the arch ring varies from 10 in. at the crown to 18 in. at the extremities of the center segments and to about 4 ft. at the springing line.



View Showing Special Falsework under Reinforced Concrete Arch.

The reinforcement is made wholly of plain round bars of medium steel in two sets, one of them near the upper and the other near the lower surface of the concrete. In the lower set there are eighty curved rods 1¼ in. in diameter and 30 ft. long which reach from the footing to a point near the crown where they overlap 40 rods of the same diameter 24 ft. long. The upper bars correspond to them in relative position and number but are only ¾ in. in diameter at the crown, those at the end being 1¼-in. rods. The rods in both sets are crossed by horizontal ½-in. rods parallel to the axis of the arch and spaced 15 in. apart on centers. Each footing is reinforced by forty ¾-in. rods 6½ ft. long and 12 in. apart, perpendicular to the resultant. These are crossed by two full-length ¾-in. horizontal transverse rods at the extremities of the curved rods in the upper and outer sets of the arch ring. The arch is 40 ft. long inside the parapet walls, and its axis is inclined 74 deg. with that of the roadway. At each end the spandrel walls, which are not shown in the accompanying photograph are continuous with the intersecting wing walls. the latter being oblique both to the axis of the street and to the axis of the stream. The bridge contains about 200 cu. yd. of 1:3:5 concrete mixed wet by hand, Vulcanite Portland cement and broken stone varying from ¼ to ¾ in. in diameter being used. There are about 30 tons of steel in the reinforcement and the arch was built in ten working days after the completion of the falsework.

The stream was considered treacherous and subject to unexpected floods, and as the contractors did not know the character of the bottom it was decided not to trust falsework bents placed in the bed of the stream. The locality was not such that it was convenient or economical to drive piles, and it was therefore decided to support the bridge during construction on falsework trusses, as shown in the illustration. Sheeted pits were excavated to rock at a depth of 8 to 10 ft. below the surface of the ground and about 6 ft. below water level. These were drained without serious difficulty by a centrifugal pump and the lower ends of the arch ring, which really acted as skewback piers, were built in them about up to the springing line. They were allowed to set and served as supports for the falsework, which was made of simple wooden trusses about 3 ft. apart. Each truss was built of 3x10-in. planks spiked together at intersections and serving to support the top chord, which was composed of scarf boards carefully cut to the curve of the intrados. The trusses were built in place and the light radial members seen in them are small strips of wood put in place before the completion of the truss to support the scarf boards temporarily until the connections were completed and the structure developed full strength. The trusses were braced together by intermediate horizontal planks and by the lagging, which consisted of square-edge boards planed on the upper surface. Outside forms were built in three sections at each end of the arch and the concrete was rammed in them to points above the haunches, as indicated by the angles of the extrados between the face rings. By driving out the wedges under the falsework, the latter was released three weeks after the concrete was laid, without causing any appreciable settlement in the arch. The bridge was designed and built by the Reinforced Cement Construction Company, New York City, for the Harris Engineering Co., which was the contractor for several miles of the electric road.

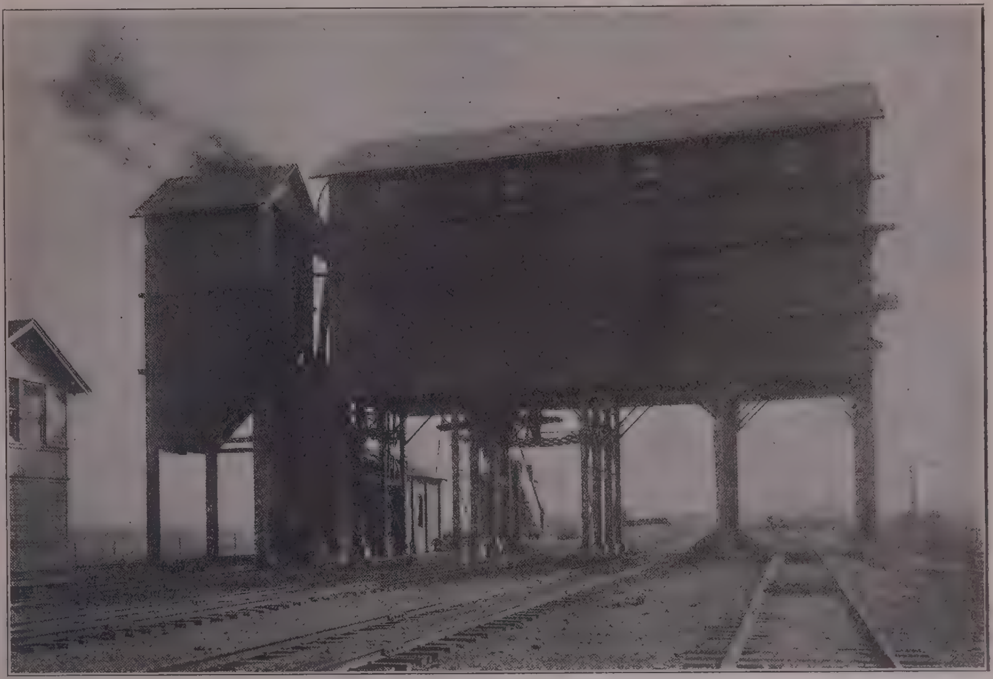
Concrete Caps for piles and sheet piling are so widely used that an inquiry recently received concerning them is somewhat puzzling. The writer asks if it is good practice to embed the heads of such piles, and if so what precautions should be taken to prevent cracks in the concrete. By keeping the piles wet and using thick concrete trouble is usually avoided.

The Watseka Coal, Ash and Water Plant of the Chicago & Eastern Illinois R. R.

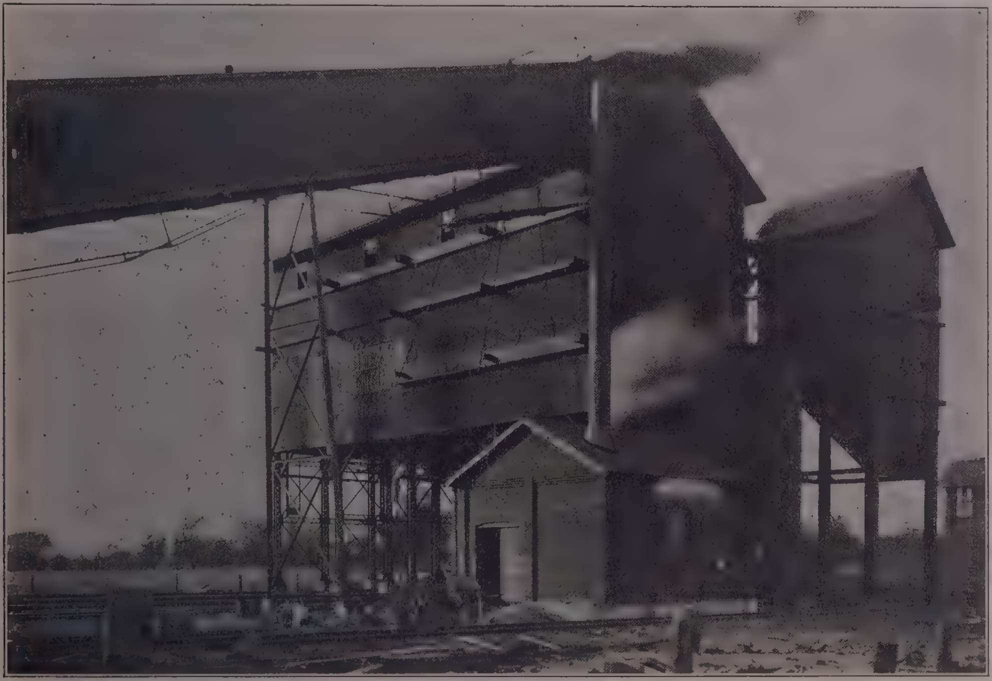
A watering, coaling and ash-handling plant with a number of advantageous features has recently been built on the main line of the Chicago & Eastern Illinois R. R. at a point two miles south of Watseka, Ill., and 79 miles south of Chicago. A very heavy traffic from the Illinois and Indiana bituminous coal fields is carried into Chicago on the main line of the Chicago & Eastern Illinois R. R. The locomotives handling this traffic from Danville, Ill., to Chicago are generally started fresh from the former place and run into a classification yard at Dolton, 17 miles from Chicago without change, a distance of 106 miles. The new plant is located about half way between Danville and Chicago, and is designed so locomotives may have their fires partially cleaned, and receive water, coal and sand at the same time.

The general arrangement of the plant is shown in the accompanying illustrations. The coal handling plant is of the belt-conveyor type, the coal being delivered to a 700-ton gravity-feeding storage pocket built over four tracks. A southbound main track, with a long passing track, is on one side, and a northbound main track, with a long passing track is on the opposite side of the center line of the pocket. Coal designated for the pocket is delivered to a switch track, with a capacity of about 20 cars, along one side of the plant. A 15x20x7-ft., steel-lined, concrete receiving hopper is built under this switch track, 190 ft. from the pocket. The switch track is on a 1 per cent. grade descending toward the hopper from beyond the latter so that cars may be moved to place over the hopper by hand. Coal is delivered in side, or bottom-dump cars, and is discharged into the hopper by gravity. A 30-in. belt conveyor built at a vertical angle of 20 degrees extends from the end of this hopper up to the top of one end of the storage pocket. An automatic feeder in the receiving hopper supplies coal to a small hopper above the belt. The belt has a capacity of handling 120 tons an hour. It delivers at the top to a steel hopper which feeds in turn a flight conveyor extending longitudinally the length of the pocket. This flight conveyor is fitted with an automatic traveling tripper with which the coal may be dumped from the belt at any point in the length of the pocket. The bottom of the pocket is pitched so that the coal will be delivered to one side of the pocket over the northbound tracks and to the opposite side over the southbound tracks. A down-spout and an under-cut gate over each track feed coal directly to the tenders of the locomotives.

The pocket stands on a steel framework set on concrete footings, and is built high enough above the tracks so that trains may pass under it at full speed with safety. The pocket is of heavy timber construction, covered with galvanized corrugated sheet steel. The covering of the belt conveyor is also corrugated sheet steel. The bottom of the pocket and of the inclined belt conveyor covering are built of Adamant plaster reinforced with expanded metal, in order to keep out sparks. The structure is covered with a prepared granite roofing and is believed to be safe from sparks from the locomotives.



Coaling Plant of the Chicago & Eastern Illinois R. R.



Coaling Plant of the Chicago & Eastern Illinois R. R.

The sand used by the locomotives is also delivered from cars to the receiving track hopper and elevated from the latter by the inclined belt conveyor to the hopper over the end of the coal pocket. The bottom of the hopper at the upper end of the belt conveyor is arranged so it will feed coal to the flight conveyor, or when sand is being brought up will feed it through an 18-in. steel pipe into a circular reinforced-concrete storage tank, with a capacity of 100 tons, at one end of the coal pocket. This tank is 12 ft. in diameter, 32 ft. high and has a conical bottom, the lowest point of which is 8 ft. from the ground. A tight circular drying room 12 ft. high is formed below the bottom of the tank by continuing the sides of the latter down to the footings. A conical stove and sand-dryer is placed concentric with a 24-in. opening in the bottom of the tank. The stack from the stove passes up through the center of the storage tank and assists the drying process. As the sand is dried it flows from the annular opening between the stove and the opening in the bottom of the tank to the brick floor of the dryer room, on which it is screened. The screened sand is dumped into an air-tight steel drum, 3 ft. in diameter and 3½ ft. deep, depressed below the floor of the dryer room. It is transported by pneumatic pressure from this drum to two small storage bins over the tracks, from which it is fed by gravity to the locomotives.

The method of transmitting the sand from the drum to the storage bins is such that very much of the wearing effect on the carrying pipe caused by the sand blast method formerly used for such purposes is avoided. A 4-in. steel pipe extends from the drum to the storage tanks. When the drum is filled to the proper depth with sand it is closed and air pressure is turned on the surface of the sand causing the latter to move out through the 4-in. pipe in a solid column to the storage bins until the drum and pipe have been emptied. The placing of the pipe in the drum, the proper amount of air pressure and other details connected with the arrangement of the sand transmission by air all have to be exactly determined to successfully handle sand by this process.

A concrete pit 50 ft. long is built under each of the four tracks at the plant to receive the cinders from the locomotives. Each of these pits is provided with two ¾-ton rectangular steel buckets fitted with a bail. Each bucket sets loose on a 4-wheeled truck running on a track in the bottom of the pit so it may be moved to suit the location of the locomotive on the track over the pit. An inclined trolley track made of a 12-in. I-beam, is attached to one side of the coal pocket and extends the length of the latter to an elevated reinforced-concrete cinder bin along the coal-receiving switch track. This bin and trolley track are shown in the accompanying view looking south. The filled buckets in the cinder pit are hoisted to a double-block steel trolley on this track by a cable on a Lidgerwood hoisting engine in the engine house of the plant, and then moved up the track to the cinder bin by the same engine. The contents of the buckets are dumped into the bin at the end of the track by an automatic tripper. The empty buckets are carried back to position over the pit and lowered into place with the hoisting engine and trolley blocks.

The reinforced-concrete cinder bin has a capacity of 75 tons. Its bottom is lined with brick and is sloped toward the switch track so that the cinders may be discharged readily through a gate and spout on the side, into an empty coal car on that track. The bin is carried by four reinforced-concrete columns, one at each corner, which are built monolithically with the remainder of the structure.

The machinery of the plant is operated from a fireproof brick engine house at one end of the coal pocket. This house contains a 50-h.-p. boiler, a 25-h.-p. Wachs engine; a Star compressor, with a capacity of 25 cu. ft. of free air a minute, the Lidgerwood engine used to operate the cinder handling apparatus and a high pressure water pump for fire protection. The engine drives the belt-conveyor through a rope drive connected by gearing to the shaft of the pulley at the upper end of the belt conveyor and to the shaft of one of the head pulleys of the cross conveyor. The automatic feeder in the receiving track hopper is driven through a gearing attached to the shaft of the adjacent pulley of the belt conveyor. The air compressor furnishes air to transmit the sand from the receiving drum to the small storage bins.

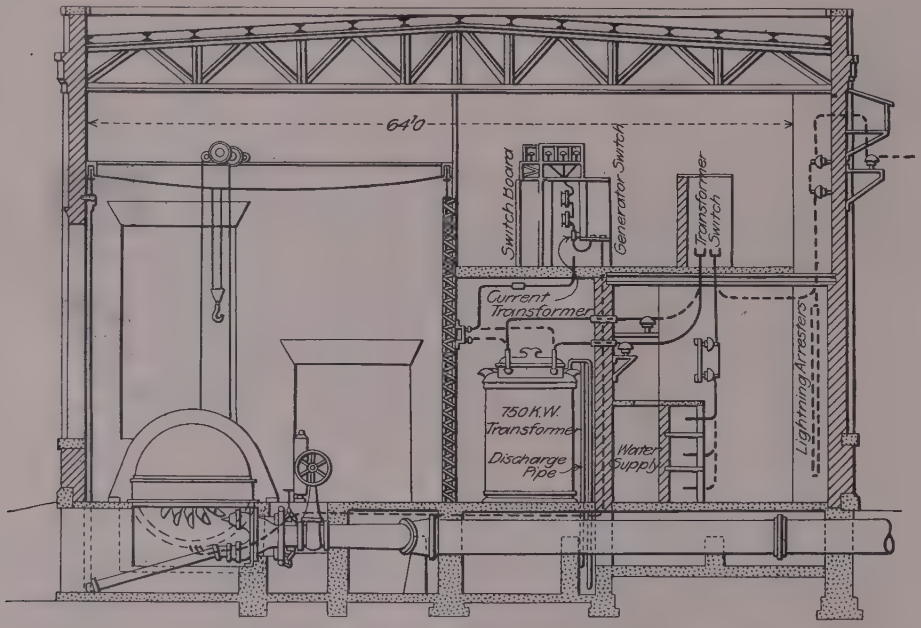
A water crane is placed between each pair of tracks so that two locomotives can be supplied at the same time. The water supply is furnished directly from a tank adjacent to the plant, pumps at a water softening plant about one mile distant supplying the tank. The fire pump in the engine house is also supplied from this tank.

The plant was designed and built under the direction of Mr. E. E. Barrett of the railroad department of Roberts & Schaefer Co., consulting engineers and contractors, Chicago, Ill. Mr. W. S. Dawley is chief engineer, and Mr. R. H. Howard, engineer of maintenance of way of the Chicago & Eastern Illinois R. R.

The Hydraulic Power Development of the Animas Power and Water Co.

By George M. Peek, New York.

The Animas Power & Water Co. was incorporated in Colorado for the purpose of building irrigation canals, reservoirs and developing water power. The first work of importance undertaken by the company was the building of the Animas power plant, which is located on the Anamas River and a branch of the Denver & Rio Grande R. R., about half way between Durango and Silverton, just above the Animas Canyon. The site is shown in an accompanying illustration. The country is so rough a wagon cannot reach the plant except by means of the railroad.



Cross-Section of the Animas Power Station.

General View of Animas Canyon where Power House is Located.

The power house is a 108x64-ft. brick and concrete building with a roof of steel and concrete, making it as nearly fireproof as possible. The building was erected to accommodate four units, only two of which are at present installed. The others are to be put in later. The leading features of the building are shown in the cross-section and photograph. The company has at present contracts for more than 4,000-h.-p.

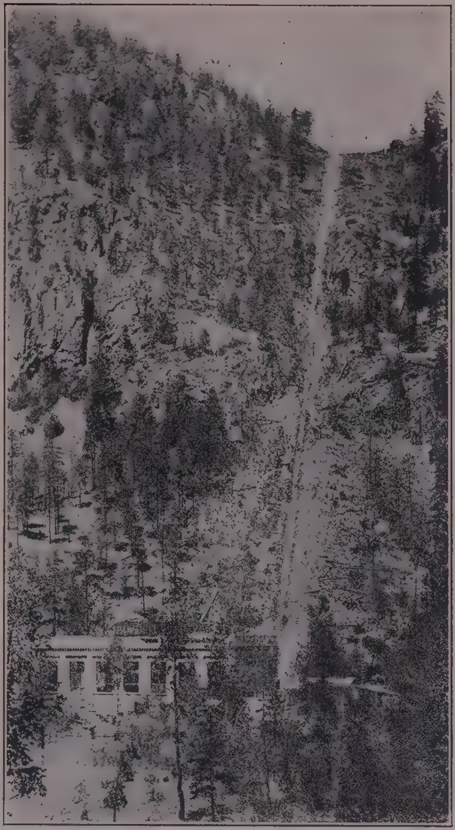
The power is derived from water taken from Cascade Creek and the watershed tributary to the large reservoir. Cascade Creek has a flow of 3,720 cu. ft. per minute and the watershed of the reservoir has 1,500 cu. ft. more, making a total available water supply of 5,220 cu. ft. per minute. The water is diverted from the creek and runs through a wooden flume 3½ miles long, which is 6x8 ft. and laid on a grade of 0.2 per cent. From the flume, water flows into a natural water course and empties into a reservoir, which has an area of 960 acres.

The reservoir was made by building a stone and timber dam about 750 ft. long and 55 ft. high, with a foundation 33 ft. deep to bed rock. It is proposed to replace this dam by one of concrete 100 ft. high and about 1,400 ft. long. This will increase the area of the reservoir to 1,161 acres. When the concrete dam is built, the company expects to take the water from Lime Creek into the reservoir, which can be done by building another flume 4 miles long. When the water from Lime Creek is added, the available water supply will be double or 10,440 cu. ft. per minute. At some future time as the demand for power increases, it is proposed to use the water from the Animas river. In order to accomplish this, it will be necessary to build a tunnel eight miles long, and when this is done there will be sufficient water for developing some 38,000 h.-p.

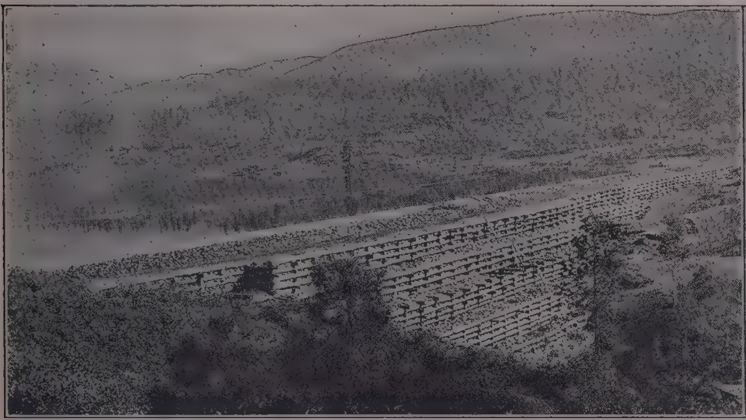
From the reservoir the water is taken in a 38x56-in. wooden flume 8,800 ft. long, laid on a grade of 0.25 per cent., which empties into an intake reservoir. The construction of the flume is shown in an accompanying illustration. The intake reservoir has an area of about 5 acres. Its dam is of earth, with a concrete core wall 3 ft. thick and another concrete wall at the inner toe. At present it is 30 ft. high, by about 100 ft. long, but it is to be raised 10 ft., which will give an effective head of 970 ft. at the power house.

The pipe enters the intake reservoir 25 ft. below the surface of the water, thereby avoiding any possibility of ice entering or blocking the pipe. In front of the pipe is located the usual screen made of flat bars of steel. The end of the pipe is tapered to 60 in. in diameter; where it emerges from the dam it is 44 in., and has a gate valve and a 10-in. standpipe on the lower side to admit air, so as to prevent any danger of collapsing the pipe in case the valve is rapidly closed. The standpipe passes through the gate house and is enclosed in a wood flue. The heat from a stove in the gate house passes through the flue and around the standpipe to prevent the water in it from freezing.

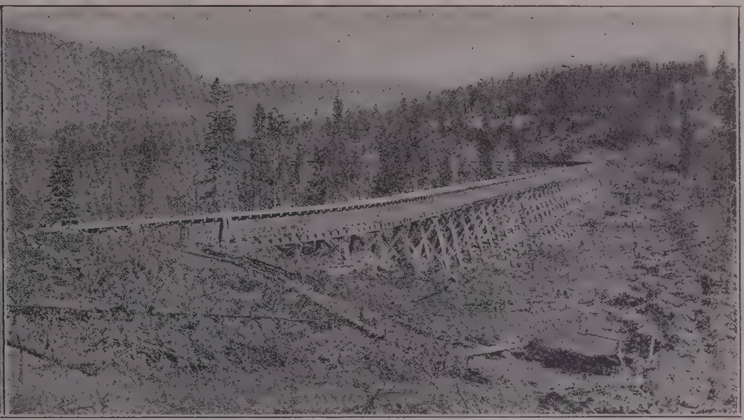
It would appear that nature had intentionally left an opening in the cliffs for a pipe line to come down from this reservoir to the power house. Starting at the top, where the elevation is 987 ft. above the station, the pipe is 44 in. in diameter by 3/16 in. thick and runs for some 800 ft., on a slight grade over the mountain to a point where the head is 125 ft. and the pipe is thickened to ¼ in. From this point downward the metal in the pipe increases in thickness to 11/16 in. and the diameter changes to 40, 36 and 34 in.,there being an equal quantity of each diameter. The pipe is 2,842 ft. long and is double riveted in the longitudinal seams and single riveted in the girth seams, down to 560 ft. head. From this point it is double riveted in the longitudinal seams and single butt-strapped and single riveted in the girth seams down to a point where the head is 975 ft. and from there to the bottom the pipe is double butt-strapped and triple riveted in the longitudinal seams. The riveted joint efficiency is 82 per cent. The pipe is made up in sections 30 ft. long and fitted with welded steel angle flanges. The flanges are bolted together with combination copper and lead gaskets between them. The gaskets are made with one ring of ⅛-in. copper wire just inside of the bolts, then comes a lead ring 3/16 in. thick and inside of this a 5/16 in. lead ring. The three rings are held together in places by solder and make a very substantial and perfectly water-tight joint. The heaviest sections of pipe weigh 6 tons each. The steepest grade on the line is 84 per cent.



Animas Power House and Pipe Line.



Main Dam.



Animas Flume.

At the power house and lower bends, the pipe is thoroughly anchored in large blocks of concrete, each of sufficient size to carry the weight of the pipe above it. The sections of pipe at the lower end were tested to 650 lb. per square inch before leaving the shops of the Pelton Water Wheel Co., which furnished the piping and water wheels. The pipe was hauled up the hill with a mine hoist and cable, and as the grade was so steep the cable could not be loosened from a section until it was in place.

At the lower end of the pipe line there is a cast steel Y, tapering down to two 20-in. branches fitted with gate valves with by-passes and roller bearings connecting to the 20-in. by-pass needle nozzles of the wheels. The nozzles are arranged with a system of toggle levers by means of which the water can be turned from the wheel through the by-pass. These toggles are arranged so that for a uniform rotation of the governor shaft, the variation in power delivered to the wheel will be constant. The by-pass is used in order to prevent shock to the pipe in case the load is suddenly thrown off the generator. The needle which controls the supply of water to the wheel and the one to the by-pass are connected by means of a right and left hand screw so that their relative positions can be changed at will by means of a hand wheel. This hand wheel can be set by the aid of a predetermined load curve and reduces the waste from the by-pass water to a minimum.

The wheels are 8-ft. overhung Pelton wheels one on each generator shaft, with a normal capacity of 3,000 h.-p. each at 300 r.p.m., but capable of being run up to 4,000 h.-p. The wheel centers and the buckets are made of cast steel. Each bucket is bolted to the wheel center with one 2¼ in. and one 1¾-in. bolt, giving ample strength to permit the wheel being locked and full stream turned on or allowed to run as fast as the water will drive it with no load on. The shafts are 14 in. in diameter at the bearings and 16 in. at the fields. They are hollow, with 5-in. holes through which water is made to circulate to assist in keeping the bearings cool. The bearings are 14x42 in., water-cooled, and are babbitted in lower half only.

The wheels are controlled by oil pressure governors with two pumps, arranged so that one can furnish power for either or both governors.

The generators are of 2,250 kw. capacity, and of the revolving field, three-phase, 60-cycle type, with the exciter armature mounted on the shaft. The generator voltage is 4,000, with step-up transformers and line voltage of 50,000.

There are six water-cooled oil transformers of 750 kw. capacity each. Each transformer is located in an iron and concrete vault, completely closed, so that in case of fire the oil cannot burn and damage any of the other apparatus.

The switchboard gallery is located over the transformer vaults. The generator mains run up through brick chambers to the oil switches and circuit breakers to the generator bus-bars. From here the circuit passes down to the transformers where the current is stepped up to 50,000 volts. The circuits then go to the high tension oil switches and circuit-breakers and from there to the transmission line. The switchboard is located near the front of the gallery and fitted with the usual instruments, together with a voltage regulator. The operator in front of the switchboard has all of the machinery in full view.

The transmission line is built of three cables, each composed of six No. 8 B. & S. aluminum wires with a hemp core and a conductivity equal to No. 2 B. & S. copper. The cables are arranged on the cross arms so as to form a triangle with 6 ft. sides. The poles are pine, 36 ft. long, and set 6 ft. in the ground 250 ft. apart. The longest span is 1,100 ft., where the cables stretch between wooden towers and span an arm of the reservois. There is a sub-station in Silverton with transformers for stepping down to 17,000 volts.

The success of the plant is very largely due to the energy and hard work of Mr. H. T. Henderson, the company's chief engineer and general superintendent.

A Superheated Steam Engine of the compound condensing type was tested some time ago, with results given in a paper by Messrs. A. Obry and P. Bonet before the Industrial Society of Northern France. Both cylinders were jacketed, the low-pressure jacket being fed through a reducing valve from the main steam pipe. An independently-fired superheater was used, but the steam piping was so long, 102 ft., that great economy was not expected. With steam at 8 atmospheres and 268° Fahr. superheat, the best result noted was a saving of 10.58 per cent. in the amount of coal per horse-power-hour as compared with the performance with the same engine when using saturated steam. The saving in steam due to superheating was 24.65 per cent. With 178° superheat the saving in coal was only 6.3 per cent., although the saving in steam was still over 16 per cent. There was a heavy loss in the pipe between the superheater and engine.

The Water-Works of Winnipeg, Man.

There is no Canadian water-works system which presents more features of interest to the engineer than that of Winnipeg, Man. The first works were constructed by a private company, but ten years ago the city authorities decided that municipal ownership offered the only way to obtain a satisfactory service for a place growing so rapidly as this. Two years were spent in obtaining the necessary legal powers for this purpose. The old works were then bought for $237,000, and their extension and improvement were immediately undertaken. All this work has been under the charge of Col. H. N. Ruttan, city engineer, who recently read a paper on the subject before the Canadian Club of Winnipeg, from which the following sketch has been derived:

Two sources for a municipal supply were investigated, the Assiniboine and Red rivers and ground water. An examination of the river from Portage la Prairie to Winnipeg disclosed the fact that the Assiniboine was the main sewer of the country—offal was gotten rid of by throwing it into the river, enclosures for cattle and pigs were fenced with a corner in the river, and barnyards were drained into it. It was felt that even the most perfect filtration would not remove the disagreeable impression, that after all, the water was nothing more or less than purified sewage, and that the only excuse for its adoption as a permanent supply for the city would be that it was the only one available. With the exception that the flow was larger, and water softer, the same objections applied to the Red River. It was found that in addition to its great cost, the Winnipeg River water would require to be filtered to remove the large quantities of suspended organic matter which it contained.

One of the ground water sources investigated was at Poplar Springs, 17½ miles from the city, where there is a large amount of water available. The cost of bringing it to the city will be large, however, and for this reason it is considered best to defer its use until later. There is a large amount of ground water within and near the city and investigations of its quality and quantity were made. Tests with the air lift showed that the water in all the wells was under the same head, and it is considered likely that the artesian basin is supplied from a number of sources. After a full review and investigation of the situation by Mr. Rudolph Herring, consulting engineer, of New York, it was decided to sink a pump well. It was estimated that from this well and a line of conduit 5,000 ft. in length, connected to tube wells, a supply of 2,400,000 imp. gal. per day could be obtained. After construction, it was found that the yield from this well alone, at a pumping depth of 38 ft. below ground level, was upwards of 2,400,000 gal. per day, and this being more than sufficient for the requirements of the city at the time, nothing was done towards the construction of the tube wells and conduit.

It shortly became evident that the city was going to grow very rapidly and that something should be done towards increasing the supply. The great quantity of water obtained from the first well completely changed the aspect of the development, and led to the substitution of the large deep well system for the tube wells and conduit first proposed.

Owing to the large flow of water, great difficulties had been experienced in sinking the first well, the inrush of water carrying with it soil from outside the well curb, undermining the foundations of the buildings, and making it necessary to stop the well short of the rock and put in a strainer of broken stone and concrete.

Looking to the necessity for taking more full advantage of the artesian supply, it was evident that the next well should be sunk into the rock, and that the curb and pumps should be placed upon the rock. It was also considered that the principal wells should be in duplicate, so that in case of an accident to one, the other could be brought into service. With these objects in view it was decided to sink well 1 into the rock and to construct well 2 as a duplicate or reserve. The system of unwatering by pumps used in the construction of well 1 had, owing to a large flow of water, proved ineffective. It was necessary, if the construction was to be under complete control such as would enable the permanent pumping machinery to be erected at rock level, and the pump suctions extended into the rock, that some other system of unwatering should be adopted. It was, after consideration, decided to use the pneumatic caisson system of sinking the well. A double steel shell caisson 18 ft. in diameter filled between the shells with concrete, was constructed at ground level, and sunk in the usual way. When water was reached, an air lock was attached to the caisson and the work of sinking continued under air pressure, sufficient to keep out the water, until the caisson reached the rock. The cutting edge was then sealed to the rock by concrete, 6-in. inlet pipes for the water being set in at rock level. A shaft 10 ft. in diameter was then sunk into the rock for a distance of 16 ft., and a gallery driven for a distance of about 40 ft. The pump suctions extend into the shaft sunk in the solid rock. This system of sinking was found to be most efficient, the water being easily controlled, and all kinds of work, including setting up the machinery at the bottom of the well, were executed without difficulty.

Well 2 yielded 4,500,000 gal. when tested soon after completion, but has since decreased on account of some obstruction in the inlet pipes by sand and gravel, which can be removed. Wells 3 and 4, under construction, will yield volumes, which are estimated by Col. Ruttan in connection with the discharge of Nos. 1 and 2 as follows: Nos. 2 and 3, 6,000,000 gal.; Nos. 2, 3 and 4, 8,000,000 gal. Well 1 will be completed like No. 2, and its yield increased to about the same amount.

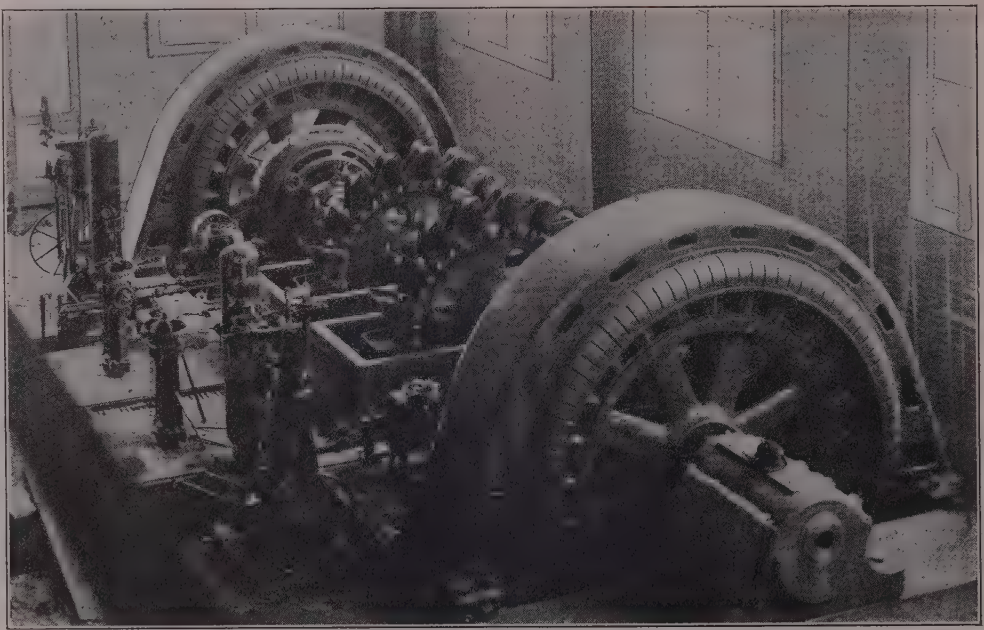
In order to equalize the draft on the wells and furnish storage capacity on which to draw in times of heavy consumption, a 6,000,000-gal. reservoir has just been completed. The water is raised from the wells by pumps of 15,000,000 gal. capacity, and is delivered to the city by a 5,000,000-gal. triple-expansion pump and an electrically-driven centrifugal pump of the same capacity.

The water is very hard and is softened before it is distributed. The artesian well water supplied to Winnipeg contains, in its natural state, the following elements, in round numbers, in the amounts stated: Carbonate of lime, 16 grains per imp. gal.; carbonate of magnesium, 8.5 grains; sulphate of magnesium, 12 grains; sulphate of sodium, 5.5 grains; carbonate of sodium, 3.0 grains; chloride of sodium, 27.5 grains. Other compounds are present in minute amounts and are of no significance in this connection. The constituents mentioned have remained almost constant in kind and in quantity for over five years.

Of the constituents mentioned, only the first three cause the water to be hard. Of these three compounds, the softening process removes only the first two, the carbonates of lime and magnesium. Sulphate of magnesium, while acting to some extent on soap, does not form any scale in boilers. In order to remove it from the water it would be necessary to add soda ash as well as lime. This would involve expense and other objections out of proportion to the benefit gained. The removal of the carbonates of lime and magnesium eliminates rather over two-thirds of the hardening substances from the water.

The carbonates in the water are held in solution by carbonic acid gas which the water dissolved from the air or soil before it was able to dissolve the carbonates of lime or magnesium from the rock. Any means which will abstract this carbonic acid from the water will soften it, because the carbonates of lime and magnesium will at once separate from the water. Boiling softens the water for this reason, but it would be impracticable and undesirable to soften a public water supply in this manner. It is possible, however, to accomplish the same thing without the use of heat. If any substance having a strong affinity for carbonic acid is added to hard water, it combines with the acid and sets free the carbonates of lime and magnesium, which thereupon separate and settle out as a white powder, leaving the water soft.

Such a substance is found in the builders' lime of the trade, the best grade being the cheapest to use. For convenience it is slaked and converted into lime water. When the lime water is



Three-Thousand-Horse-Power Water Wheels, Animas Power Station.

mixed with hard water, flakes and crystalline matter are observed to separate at once. These consist of carbonate of lime, formed by the union of the lime, which was used with the carbonic acid in the water, also the carbonate of lime which was in the hard water, and lastly, hydrate of magnesium, produced by the action of the lime on the magnesium carbonate in the hard water. It is thus apparent that all of the lime which is used for softening is converted in the process into carbonate of lime, which separates immediately from the water, bringing with it the carbonates which were in the hard water.

The apparatus for preparing and pumping up the lime cream consist of a slaking bed, a mixing well and a ball valve pump. The speed of the pump is regulated from the operating platform. The lime water is mixed thoroughly with the hard water in a baffle channel. Thence the turbid soft water flows to the bottom of two large tanks, where it deposits nearly all of its suspended matter or sludge. Rising slowly to the top, it flows off through floating discharge pipes to the filters, which give its final clarification.

There are seven filters, each one containing about 1,450 sq. ft. of filter cloth surface. Each filter runs about 24 hours. It is then opened and the cloths are removed, washed and replaced. The softened and filtered water passes into a 300,000-gal. service reservoir, whence it is pumped to the city. After passing the filters, the water is carried over perforated copper plates through which it falls like rain, into a trough through which carbonic acid is being passed. The falling water absorbs the gas and flows from the trough into the storage reservoir described above.

A description of Winnipeg water supply would not be complete without a reference to the special fire service water works now being constructed in the business center of the city. This system is to take its supply from the Red River. It is to be capable of pumping 13,000,000 gal. of water per day at a pressure of 300 lb. per square inch. The water is to be distributed by about three miles of cast iron pipes, fitted with hydrants of special design, and with hose attachments for 4½ and 3½-in. hose. The pumps being made by Glenfield & Kennedy, of Kilmarnock, will be six in number, four 13½x18 in. and two 9½x18 in. triple double acting. These will be driven by six Crossley gas engines rated in the aggregate at 2,600 b.h.p. It is hoped that this system will be in operation early next year.

The Standard Thread for Hydrants and fire hose couplings has been adopted in St. Louis, which has changed from six to seven and a half threads to the inch. This decision is a gratifying one for there are very few reasons for a continuation of the present innumerable variety of threads, which makes it difficult for the fire department of one city to assist that of another. The reform was started many years ago, but was brought about mainly through the hard work of Mr. F. M. Griswold, of New York, chairman of the committee of the National Fire Protection Association having charge of the subject. The thread has been adopted by that society, the American Water Works Association, the International Association of Fire Engineers, the National Firemen's Association, the New England Water Works Association, the Pennsylvania Water Works Association, the National Board of Fire Underwriters and local organizations. The standard thread was selected after a careful investigation which showed that a female or swivel coupling cut with it would take about seven-tenths of the hydrant threads now in use in this country. Adapters are made to connect equipment with old and new threads.

Vitrified Brick for Paving Purposes.

The National Paving Brick Manufacturers' Association was organized for the following purposes: First, a dissemination among its membership of technical knowledge relating to the manufacture of their product. Second, to bring to the attention of the public the merits of vitrified brick as a paving material. Third, to influence to the greatest possible extent the proper construction of brick streets. Fourth, for furnishing reliable information regarding other paving materials, and their comparative value as pavements when considered with brick pavements. In pursuance of the foregoing purposes the Association has caused to be prepared, out of the experience of eminent engineers, a code of directions for laying brick pavements, from which the following notes are taken:

Substructure or Grading.—Earth in excavation should be removed with plow and scraper, or other device, to within 2 in. of subgrade, then brought to the true grade with the roller, the weight of which should not be less than 5 nor more than 8 tons. If the earth is too hard to receive compression through the roller, then loosen the remaining inches with a pick and cart away. Earth in embankment must be applied in layers of 8 in. thickness and each layer thoroughly rolled, and in both excavation and embankment the subgrade must have a uniform density. If the ground is spouty clay, tile drainage should be provided to carry off the water.

The attempt to remove earth to the proper depth or grade line with plow and scraper is usually fatal to the general surface of the subgrade, for the reason that no man can hold a plow or team-draw to a straight grade; therefore, in an attempt to get too close to subgrade with a plow, holes will be gouged below the true grade. When the shovelers commence the removal of the plowed earth, they will invariably sink these same low places still lower, and when the finishing begins these places will necessarily have to be filled and compacted with the roller. Thus there arise different degrees of solidity, which are objectionable and detrimental to good work.

The prime reason for not using a roller weighing more than 8 tons is that they are cumbersome and unwieldy and very slow moving, while with a lighter and quick moving one it is possible to pass many times over the subgrade and get better results in having the subgrade more uniformly compacted.

The filling with loose earth of portions of the work below grade will be found necessary very often if an attempt is made to plow too close to the grade line; then the lighter roller is found more effective in bringing such places to the same density as the undisturbed portion.

When embankment is necessary to bring the street to the required grade line, it is obvious that the earth should be deposited in equal layers not more than 8 in. thick, and each layer thoroughly rolled. A 6 or 8-ton, or even heavier roller will have little effect in compression below 8 in. All embankments should be compacted as thoroughly as possible before applying the superstructure; for earth once disturbed and removed from its natural bed takes a long time to acquire its original solidity.

Under-drainage is not an absolute essential, but in a wet and spouty understratum much is added to the durability of the structure by keeping the sub-foundation dry, and under wet conditions under-drainage is the only way to accomplish the best results.

Concrete Foundation.—This should be of approved quality of hard rock, free from all refuse and foreign matter, with no fragment larger than will pass through a 2-in. ring, and no smaller than will pass through a 1-in. ring in their longest dimensions. Clean, sharp, dry sand should be thoroughly mixed in its dry state with an approved brand of either hydraulic or Portland cement until the whole mass shows an even shade. If hydraulic, the proportion of mixture should be one part of cement and two parts of sand, if of Portland, one part of cement to three parts of sand. To the above mixture should be added sufficient clean water to mix to a plastic mass, fluid enough to rapidly subside when attempting to heap into a cone shape. To this mixture add four and six parts, respectively, of damp crushed stone, or good gravel carrying sufficient sand to make the mixture, and turn the whole mass over not less than three times, or until every fragment is thoroughly coated with the cement mixture. For the reception of this mixture, the grade should be set off in 5-ft. squares, with a stake at each corner. The top of each stake should be at the surface of the concrete, which must be tamped until free mortar appears at the surface. Occasional sprinkling in extra hot, dry weather is beneficial. After thirty-six hours the cushion sand may be spread.

Sand Cushion.—Sand should be clean and free from foreign or loamy matter. It need not necessarily be sharp. It should be 2 in. thick before the compression of the brick by rolling. The sand should be spread by the aid of a template the whole or one-half the width of the street, and made to conform with the true curvature of the street cross-section.

The preparation of the subgrade having been, with care, brought to a uniform thickness, the work is ready for the cushion for the brick, for which any good clean sand may be used whether it be sharp or spherical, but it is next to the impossible to spread it satisfactorily with a template or any other manner when it is wet. To have the pavement maintain its symmetrical form the sand must be evenly spread, and there is but one method for doing this, by the aid of a template formed to fit the curvature of the street and armed with small metal wheels at either end, rolling on the curb at one end and on a 4x4-in. scantling laid lengthwise through the center of the street at the other. If the roadway of the street is not to exceed 25 ft. in width or less, the template can be made to span the entire width, both ends rolling on the curb.

This insures an even thickness of sand over the surface of the concrete, giving to each individual brick a like thickness of cushion, so that when the surface is rolled each brick will present the same resistance to the pressure of the roller. If the sand is of uneven thickness the tendency of those brick resting over the thicker bed of sand is to sink under the pressure of the roller lower than those resting over a thinner layer, and the result is an uneven surface.

Brick.—The brick should all be hauled and neatly piled within the curb line before the grading is finished, or if allowed by the engineer, delivered in wagons and carried from the pile or wagon on pallets with clamps—not wheeled with barrows. In hauling from the car no throwing or dumping is allowed. They should be first-class and thoroughly vitrified, showing at least one fairly straight face, if with rounded edges, with no greater radius than 3/16 in. They should be not less than 2¼x4x8½ or more than 3½x4x9½ in., free from cracks, with but slight lamination, and at least one edge with but slight kiln marks allowed, and should stand the tests promulgated by the National Brick Makers' Association.

It is not only good practice to have all of the brick hauled and distributed just inside the curb line before the work of grading begins on any street block, but it is economy, as experience has taught that it is very expensive to attempt to get brick into a block after the other work has begun. Each side of the street should have the required number of brick neatly ricked up to lay to the center of the street, thereby always maintaining the minimum distance to carry the brick to the setter. In order to get the brick to the setter with the least possible abrasion or injury it is best to carry them on pallets, and so deposit them that the person laying them in the street will deposit them face edge up. No wheeling or teaming should be permitted over the brick at any stage prior to opening the same to the public.

Brick Laying.—Brick may be laid either at a right angle or at an angle of 45 deg. to the curb as the engineer may direct, and in either way the course of brick must be kept within a maximum variation of 2 in.; if greater than that, as many courses as necessary should be taken up and relaid until the defect in alignment is removed. No parts of brick should be allowed in the pavement except the beginning or ending of courses or other closures. The brick must be laid with the best edges exposed as nearly in contact as possible; they must be closely inspected before laying and also after laying and after rolling, and all soft, badly spalled or ill-shaped brick must be removed and replaced with perfect ones. The kiln-marked bricks may be turned over, and if the reverse edge is smooth and no other faults be found, it can remain in the pavement.

As to the alignment of the courses of the brick there is but little choice. The brick should be as nearly in contact as it is possible to lay them, for when the rolling is in progress, if there is appreciable space between the brick in the compression and bedding into the cushion sand, the brick will have a tendency to rock, and instead of receiving a flat foundation, as they should, it will be in a curved form, made by the rocking of the brick as the roller passes on and off of them, and the pavement will require more grout to fill the interstices. It is not bad practice, if the gutter gradient is very flat, to lay five or six longitudinal courses parallel with the curb, as there will be less hindrance to the gutter drainage.

After the brick in the pavement are inspected and the surface is swept clean of spalls, they must be well rolled with a 5-ton steam roller in the following manner: The brick next the curb should be rammed with a wood tamper to the proper gutter grade. The rolling will then commence near the curb at a very slow pace and continue back and forth until the center of the pavement is reached, then pass to the opposite curb and repeat in the same manner to the center of the street. After this first passage of the roller the pace may be quickened and the rolling continued until each brick is firmly embedded in the sand cushion. The roller should then be started at the end of the block and the pavement rolled transversely at an angle of 45 deg. to the end of the block, repeat the rolling in like manner in the opposite direction. Before this transverse rolling takes place, all broken or injured brick must be taken up and replaced with perfect ones.

There is no question open to discussion as to the virtue of a steam roller on a brick pavement. It is very necessary in order to give it a smooth surface. The transverse rolling removes the slight wavy condition of the surface, extending laterally from curb to curb, which will occur after the longitudinal rolling and is the result of the thrust or impact occasioned by the propelling power of the roller. If the roller was drawn instead of being propelled these apparent waves would not occur, therefore, the transverse rolling will practically remove them. The longitudinal rolling should always be from curb toward the center. The curved transverse section of the street has a tendency to move the brick endwise toward the curb, therefore, under the pressure of the roller, if the roller starts in the middle and rolls toward the curb, the gutter bricks previously tamped to grade will be very much disturbed. If it were practicable to use the roller against the curb the rolling might be done from the center to the curb.

Expansion Joint.—An expansion cushion must be provided, 1 in. in thickness next to the curb, filled two-thirds of its depth with pitch, the top one-third being filled with sand. This pitch joint next to and along the curb answers two purposes, it takes up the expansion of the brick and prevents a possible cracking of the pavement through and along the center of the street, which sometimes occurs if the ends of the courses of the brick are abutted directly against the curb which acts as a skewback or haunch to the arc of the pavement, and is often strong enough to resist the force of expansion in that direction. This will find relief in raising the pavement and the cracking may occur. In taking up the expansion the brick are kept in contact with the sand cushion below, thereby preventing the rumbling noise so often heard, and occasioned wholly through lack of contact. The inch of sand on the top of the pitch joint has a tendency to prevent the pitch from flowing, which it is likely to do in very hot weather. It is essential for the board occupying the place to be filled with pitch to remain in place until after the street is in all other respects finished, but it should always be withdrawn and the pitch applied within 36 hours after the application of the cement filler.

Filler.—The filler should be composed of one part each of clean sand and Portland cement. The sand should be dry. The mixture, not exceeding one-third bushel of sand with a like amount of cement, should be placed in the box and mixed dry until the mass assumes an even and unbroken shade. Then water should be added, forming a mixture of the consistency of thin cream. From the time the water is applied until the last drop is removed and floated into the joints of the brick pavement, the mixture must be kept in constant motion.

The mixture should be removed from the box to the street surface with a scoop shovel. The box should be 3½ to 4 ft. long, 27 to 30 in. wide and 14 in. deep, resting on legs of different lengths, so that the mixture will readily flow to the lower corner of the box, which should be from 8 to 10 in. above the pavement. This mixture should be thoroughly swept into the joints the moment it touches the brick. Two boxes should be provided in case the street is 20 ft. or less in width; for streets over 20 ft. in width, three boxes should be used.

The work of filling should be carried forward in line until an advance of 15 to 20 yards has been made, when the same force and appliances should be turned back and cover the same space in like manner, except that the mixture for the second coating may be slightly thicker than the first. To avoid the possibility of thickening at any point, there should be a man with a sprinkling can, the head perforated with small holes, sprinkling gently the surface ahead of the sweepers.

Within one-half to three-quarters of an hour after this last coat is applied and the grout between the joints has fully subsided, the whole surface must be slightly sprinkled and all surplus mixture left on the tops of the bricks swept into the joints, bringing them up flush and full. After the joints are thus filled flush with the top of the bricks and sufficient time for evaporation has taken place, so that the coating of sand will not absorb any moisture, one-half inch of sand shall be spread over the whole surface, and in case the work is subjected to a hot summer sun, an occasional sprinkling, sufficient to dampen the sand, should be given for two or three days.

Firing Boilers With Coke Oven Gases.

Tests of boilers fired with coke oven gas show that results are influenced by the area and position of the main gas-flue, the height and capacity of the chimney, and the number of hours that the majority of the ovens have been burning at the time that the boiler-duty is being obtained. That duty varies at different times of the day, Mr. T. Y. Greener stated in a paper before the Institution of Mining Engineers, and is usually lowest between 8 and 11 a. m., by reason of the fact that the majority of the coke-ovens it is intended to draw that day are by that time unloaded and are being charged, most likely with washed coal; hence, the temperature of the main gas-flue is cooled by the admission of cold air and to some extent by the water in the coal. As a result of that cooling, the efficiency of the boilers is reduced for the time being. It is not prudent, therefore, to rely absolutely on coke-oven boilers for an adequate supply of steam, and most coking collieries provide one or two hand-fired boilers to be used only at such times as those on the ovens are not steaming their best. Mr. Greener has one colliery under his charge at which hand-firing is never necessary, and several others at which it is only resorted to on very rare occasions.

In preparing comparative figures, an endeavor should be made to have the tests continued over a sufficiently long period in each case, so as to determine the duties of the several boilers during coal-drawing hours. The results in the night would undoubtedly be better than those in the day, and the boilers would be capable of producing more steam, because the ovens are all closed up and those loaded during the day are burning freely. Obviously, therefore, there would be a more ample supply of steam at coking collieries in the day, if the ovens were drawn at night instead of during coal-drawing hours. Difficulties would, however, arise with the workmen if such a system were generally adopted at beehive coke-ovens, and the probability is that coke loaded in the night shift would not be so carefully selected as that loaded in the day-shift, and would, therefore, not be so readily saleable.

Mr. Gerald H. J. Hooghwinkel wrote in discussing the paper that Babcock & Wilcox, Stirling and five-flued boilers were improvements on Lancashire and antiquated egg-ended boilers, because of their better heat-abstracting qualities. These boilers also did not require economizers to be attached, but the chimneys should be much higher. For bee-hive coke-ovens, without bye-product recovery-plant, a water-tube boiler was the best steam-producer; but, with modern bye-product coke-ovens, the intermediate use of steam should be abandoned, and the cleaned gases should be used direct in gas-engines. This had been done for some years on the Continent, notably in Germany, and it was now incorrect to say that this means of power-production was still in the experimental stage. After the usual preliminary deceptions, due to insufficient knowledge of the composition of the waste-gases, no trouble had been experienced. The question of cleaning the waste-gases and the proper size of this cleaning plant and gas-engine plant presented many interesting questions, which, however, had been solved to the entire satisfaction of gas-engine experts.

The Depreciation of Electric Plant which should be written off annually is indicated in a way by the fact that when an isolated plant which cost the city of Columbus, Ohio, $63,000 about seven years ago, was advertised recently, only one bid of $1,800 was received for it. The annual depreciation at this rate was 9.7 per cent.

Book Notes.

The "Proceedings" of the convention of the American Society of Municipal Improvements, which was held last September in Montreal, have been published in a book of 278 pages, which contains a large amount of information of value to city officials, particularly to those connected with public works. The contents include papers and discussions on public bookkeeping, municipal franchises, local assessments, parks, pavements, garbage disposal, street lighting, the copper sulphate experiments made in New York, the anti-mosquito campaign in New Jersey, sewerage and sewage disposal, and the like. Special attention should be paid to a paper by Mr. E. J. Fort on the organization and conduct of the Brooklyn bureau of street repairs. Very little has ever been printed on this subject, and as the paper gives a large amount of detailed information it will be found unusually valuable. The book is sold by the Society's secretary, Mr. G. W. Tillson, Municipal Building, Brooklyn, at $1.00.

A paper which deserves the thoughtful attention of all who are interested in municipal ownership is Dr. Frederic C. Howe's "Municipal Ownership in Great Britain," published by the U. S. Bureau of Labor in its "Bulletin" for January. It is particularly useful because it represents the results of an investigation by an experienced student of such problems, who recognizes that the mere fact of municipal or private ownership and the profit or loss entailed by it is simply one factor in the problem. He points out that the reason for the great progress in municipal trading in Great Britain has been largely due to the fact that the system of taxation there is wholly unlike that in the United States. Local taxes are largely assessed against the tenant or occupier and not against the owner, as here, and consequently the poorest tenants take a very direct interest in the tax rate. Anything which promises to keep it down will receive the approval of the voters, particularly as the public works of British towns are kept free from the political maladministration which characterizes some departments of so many American cities, and the British voters have good grounds for believing that the character of public and private business administration is a uniform one. Then again, franchises in Great Britain have almost always been recognized as granting monopolies, and while Parliament, which alone gives them, except in the case of telephone franchises issued by the Post Office Department, has been careful to prescribe many limiting conditions rarely present in American franchises granted by cities and States, the British public felt that such monopolies should be held by public authorities rather than private companies. Dr. Howe begins his paper with an explanation of the methods and scope of municipal ownership in Great Britain, and then reviews the criticisms of it and the arguments advanced for it. He then passes to an explanation of the relation of Parliament to the cities, which is entirely unlike anything in the United States, and describes the method of local administration. After this general review of the subject, the broad results of the municipal ownership of water, gas, street railway, electricity, telephone systems are stated, the effect of municipal ownership on the employes of public service undertakings is reported at considerable length. The report closes with a detailed statement of what municipal trading has done in each of the large cities of the kingdom. It is easy to see that the author believes municipal ownership has proved successful in Great Britain, but he makes no statement concerning American conditions.

A few months ago mention was made in this journal of the "Lecture Notes on Some Business Features of Engineering Practice" prepared by President Alex. C. Humphreys for the students at Stevens Institute. It is a book every engineering student should master, for there is no profession calling more emphatically for business knowledge than that of engineering. The engineer, as is often remarked, is a man who can do for one dollar what any fool can do for two dollars, and a reason for his ability to accomplish this result is because he knows the importance of business principles. Unfortunately, there are many people who consider themselves engineers who have never progressed beyond the stage of scientific empiricism. Their structures and machines may be technically correct, possibly they are examples of brilliant applications of the laws of nature to the uses of man, but they fail because they are impractical when measured by the pitiless standards of the business man. It is for this reason that President Humphrey's book is so useful. It is referred to again because he has just issued a supplement in which the subjects of agency, partnership, negotiable instruments and depreciation are discussed at length. This pamphlet, which is sold by Stevens Institute, Hoboken, N. J., is particularly valuable because so many young graduates take places as agents of companies or individuals without any clear idea of their legal obligations. Moreover, the partnerships between engineers and architects are notoriously prone to cause trouble, probably because they are entered into without a clear comprehension of their obligations. Choosing a partner is almost as serious as choosing a wife, in some respects, yet a good many young engineers rush into such a relation without any reflection of the troubles it may produce.

An Elementary Treatise on Photographic Methods and Instruments. By J. A. Flemer. New York, John Wiley & Sons; cloth, 8vo, 458 pp., 109 plates, $5.00.

The use of the camera in topographic work has so long passed the experimental stage that the absence of any good book in English on the subject has been surprising; in fact, the lack of such a book is probably one of the reasons for the failure of photography to advance more rapidly. Mr. Flemer has supplied the missing information in a very complete manner; in fact, the most adverse criticism of his book is the detail of some of his explanations and the amount of space given to subjects that have but the slightest value, except historically. This makes his volume useful for reference or for study, but unfits it for field use. Just at present there is a real need for a concise book of not more than a hundred pages of small size, giving complete directions for the field and office practice of the art. All this information is given by Mr. Flemer, but it is in connection with so much more explanatory and historical matter that it is somewhat hidden.

The author begins with a chapter on the most important topographic surveys made with the camera in all countries where such work has been done, and gives some bibliographic notes which will be of service to those who desire to investigate the subject further. Then he explains the elements of central projection and describes the construction and use of a pin-hole camera. With the fourth chapter he begins the discussion of the practical features of the subject and explains the fundamental principles of iconometric map plotting. The orienting of the picture, the arithmetical determination of the principal point and horizon line on the photographic perspectives, various special problems of orienting and methods of mapping from plates exposed in vertical planes are explained in a satisfactory manner. In the next chapter the same information is given regarding plates exposed in an inclined position. These two chapters explain the principles on which phototopography depend, and an understanding of them is necessary for a comprehension of the field practice.

In the sixth chapter the author explains the leading surveying methods in which the camera is employed. The methods of Jordan, Le Bon and Paganini are described, as well as the arithmetical methods of finding the plotted positions of terrene points when pictured on vertical and inclined exposures and the elements of a photographic perspective. These arithmetical methods are not likely to prove so useful, however, as the graphical iconometrical plotting systems. The author gives details concerning six of these, the French method of Col. A. Laussedat, the German method of Dr. A. Meydenbaur, the Canadian method of Capt. E. Deville, and the methods of Commandant V. Legros and Prof. S. Finsterwalder. This is probably the most comprehensive explanation of the field methods of phototopography that is available in English and makes the book a valuable one in any engineering reference library.

The explanation of the principles of camera lenses will be found a useful section of the book to engineers, because such lenses are radically different from those employed in the usual surveying instruments. The author would have done well to emphasize the absolute importance of high-grade lenses for successful phototopography; rapidity is not specially necessary, but other requirements must be rigidly satisfied in order to obtain good negatives. Very few camera manufacturers appreciate these special needs and the author's suggestions are particularly valuable on this account. His description of the different types of cameras that have been used for surveying purposes is detailed to the point of prolixity. Some of the instruments mentioned were essentially experimental and others were not very successful, and while an account of them is well enough for reference, the space taken up by their description renders the book bulky without compensating advantage to most readers.

The explanation of the photographic methods in the field is a useful chapter, most of which, however, relates to the development of plates, fixing the negative and printing. A large amount of information is furnished, but it is not always certain that the methods described have been tested by the author and found to be satisfactory. The book closes with some general remarks on phototopography, in the course of which the author gives his opinion concerning the precision of such work. The slowness of the office work is held to be its main drawback, the plotting of fifteen to thirty control points being a good day's work. The main advantage is the rapidity of the field work, but this is dependent on the weather to a considerable extent. It is generally unnecessary to spend more than an hour and a half at a camera station, provided the weather permits views to be taken.

Valves and Valve Gear Mechanisms. By W. E. Dalby. New York, Longmans, Green & Co.; cloth, large 8vo, 378 pp., $6.00.

Prof. Dalby has written a book bearing the above title which will find a place at once on the shelf holding the few engineering treatises of the first rank. It has but one defect—its title—which does not indicate that the contents are restricted to gears in which there is only one position of the valve for each position of the crank, thus omitting the gears in which a governor is included in the mechanism operating the valve. These latter gears cannot be discussed from kinematic considerations alone, but require the introduction of dynamics. Within the limits chosen by the author the treatment of the subject is entirely satisfactory, being both clear and scholarly, while the arrangement of the chapters is such that the student is taken along over the path of least resistance, beginning with graphical methods of analysis and ending with the representation of the valve displacement by a Fourier series, a powerful and searching method of analysis which is much used in dealing with electrical problems, but is rarely employed in other engineering branches, even when it is eminently suited for the investigations. Attention is particularly drawn to the author's brief discussion of the principles on which the Fourier method is based, for it will prove of interest to those who have not become acquainted with it.

The first six chapters of the book relate to valves and the distribution of steam effected by the simple eccentric gear. The cycle of operations is first explained, and then there is a description of steam-distributing valves in which all the leading types of Europe and America are described, with the aid of excellent illustrations. It should be added that the illustrations throughout the volume are of as high order as the text; all valve diagrams are drawn to represent the motion of the valve as it would appear to an observer looking at the engines from a position where the cylinder is seen to the left of the crank shaft, and the zero crank position is always that of the crank in the line of the stroke where the crank is seen to the right of the crank shaft. The chapter on the crank and connecting rod explains the various graphical methods of working out their motion and is particularly useful on account of the excellent advice given concerning the advantages and defects of each of them. After disposing of the fundamental principles of the subject in this manner the simple eccentric gear is then taken up. The oval, Zeuner, Reuleaux, Bilgram and other diagrams are described, many examples are worked out and numerous hints are given for the solution of all the special problems that arise with such gears. Afterward the same treatment is given to independent cut-off gears, such as the Meyer, Rider, Corliss and Sulzer. Finally the analytical methods of solving the problems which have been previously worked out wholly by graphics are explained.

The next part of the book is devoted mainly to reversing gears. Their properties are first worked out graphically and then subjected to analytical examination from which rules are formulated by means of which the distribution of steam the gear can effect may be found approximately, without the labor of drawing the actual displacement curves. The author acknowledges his indebtedness to Zeuner and Rankine for the basic idea of many of these methods. The illustrations show the gears employed on many locomotives and ships, and include excellent discussions of the Stephenson, Gooch and Allan link motions and the Walschaert, Hackworth, Marshall, Brown and Joy gears and related subjects. These two chapters alone will make the book invaluable to anybody interested in locomotive design and the construction of marine engines.

The next portion of the book is a discussion of certain dynamical problems connected with high-speed valve gears, the methods used being those explained about twenty years ago by Prof. R. H. Smith and since elaborated in his book on "Graphics." The standard Joy gear of the locomotives of the Lancashire & Yorkshire Ry. is employed, and each link of such a gear was tested to determine its dynamical characteristics. Other dynamical problems relating to connecting and eccentric rods are likewise discussed. In preparing this chapter the author has not only written an excellent discussion of important technical features of high-speed gears, but he has also furnished a connected treatment of all the principal theorems of the motion of a rigid body in a plane which is recommended to teachers of applied mechanics as affording excellent class room exercises in that subject, for the problems may be presented without a detailed knowledge of the information in earlier portions of the book. Finally, the book closes with the discussion of valve displacement by means of a Fourier series, as previously mentioned.

Letters to the Editor.

Five-Centered Arches.

Sir:—I enclose a print which gives a graphic method of laying out a five-centered arch, and also an analytical solution of the problem. This matter lately came up in my office, and never having seen any simple formula for a five-centered arch, I worked it out with the help of one of the draftsmen.

To plot the intrados of such an arch, having given the span and rise, let *AB* represent the span and *CD* the rise. Join *A* and *D*. Draw *FO* perpendicular to *AD*. Make *CP* equal to *CD*, and describe a semi-circle on *AP*. Make *CN* equal to *ED* and describe the arc *MN* from the center *O*. Make *AL* equal to *CE* and describe the arc *LM* from the center *K*, cutting *MN* at *M*. *K*, *M* and *O* are the centers and *AK*, *MH* and *OI* are the radii.

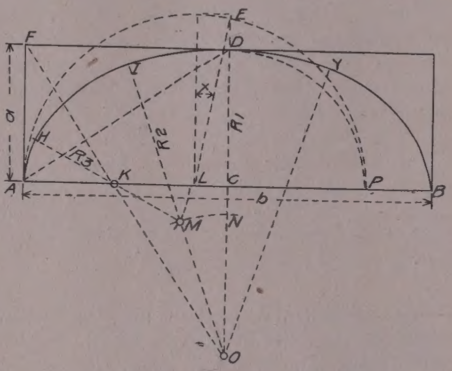


Diagram of Five-Centered Arch.

The analytic solution is as follows: $R_1 = b^2/4a$. $R_2 = \cos x \, \tfrac{1}{2}\,(\tfrac{1}{2}b + a)$. $R_3 = 2a^2/b$. $\sin x = (\tfrac{1}{2}b - a) \div (\tfrac{1}{2}b + a)$. $OM = R_1 - R_2$. $KM = R_2 - R_3$. $OK = (R_1 - a) \div \cos FOD$. $\tan FOD = 2a/b$. Substitute the numerical values of *OM*, *KM* and *OK* in the following equations:

$\cos KOM = (OK^2 + OM^2 - KM^2) \div (2OK \times OM)$ $\sin KMO = \sin KOM \times OK \div KM$ Angle IOD = angle FOD — angle KOM. Angle $HMI = 180° - \text{angle } KMO$, Angle $AKH = 90° - (HMI + IOD)$.

Thinking that these solutions will probably be of use to some other engineers I am glad to submit them.

Yours truly, A. Swartz.

New York, March 31.

Improving the Appearance of Concrete.

Sir:—Does it not seem to you that engineers are running considerable risk in putting up so many structures with blank, dull, flat concrete surfaces in conspicuous places? As a mere contractor, and a Western one at that, it is folly for me to make any protest, however mild, against some of the structures that I am building, yet for the sake of the work itself and the business reputation of our firm, I will be glad to pay out quite a sum to reduce the offensively uniform appearance of their exposed surfaces. We will shortly begin the construction of some retaining walls in which the engineers have introduced buttresses and panels in a way that an architectural friend tells me will produce a satisfactory breaking of the surfaces. The projections and recesses are so bold that, as the work lies almost north and south, there will generally be some strong shade lines on the faces. This architect says that it is important to break up the surfaces in this manner, and as the cost of doing so is insignificant I am naturally much interested in the result of the experiment. It was tried on the Illinois Central wall on the Lake Front here, which you illustrated a few weeks ago, and the result is quite effective, but the projections on the work we will put under construction in a few days are much more emphatic, and accordingly the test will be better.

It seems to me, however, that these surface moldings will by no means solve the problem. Of all the materials which are used in building work, concrete has the least character. It is a dull, neutral material which has a dead appearance when at its best and a decayed appearance when the surface is streaked and blotched by efflorescence and discolorations. When the work is not carefully done there are often great damp patches which are very unsightly. Although a number of contracting acquaintances have gone into the construction of reinforced concrete buildings and other structures, we have never cared to do so because we have yet to meet the owner of such a building who is not disgusted with its appearance, and we do not care to turn over to an owner anything but satisfactory work. Of course, the contractor is not responsible for the appearance of a building when he follows out the plans and specifications strictly, but nevertheless it really seems to me that he is justified in making a sober protest against being required to produce an attractive building out of concrete. I am told that the flatness and dullness can be removed by the use of special grades of sand and by treating the surface in special ways, but I never saw anything of the sort and so do not personally know what these methods will accomplish.

Inasmuch as a large amount of concrete work will be carried out during the coming building season, it seems to me that a discussion of the methods of securing a more satisfactory appearance of the work than it usually presents would be of much value to engineers, architects and contractors. My own contribution to the discussion is simply the suggestion that the surfaces should be broken by strong buttresses and panels, designed so as to avoid sharp corners and yet have sufficient projections to cast good shadows. Sharp corners cannot be made of concrete satisfactorily; even the best of them soon chip away, and the work becomes unsightly.

Yours truly, Contractor.

Chicago, April 6.

Windmill Tests lasting two years were recently described by M. Ringelmann in the "Comptes Rendus." They were made with a windmill 3.6 m. in diam. having 72 sails 1.3 m. long and a total surface of 9.39 sq. m. The mill was worked regularly with wind velocities between 4 and 10 m. per sec.; above the speed corresponding to the higher velocity the mill was stopped. In the trials 1 revolution of the mill required 43 kg.-m. The mechanical efficiency of the mill, gearing and pump (actuated by the mill) was 34.1 per cent. It is found that if V is the wind velocity in m. per sec. and v that of the wind, $v = nV$, where n varies between 0.88 and 0.75. If T is the mechanical energy in kg.-m. per sec. capable of being obtained from the wind acting on the surface A sq. m. (projected surface of sails) in area, then $T = KAV^3$, where K is a coefficient which, with constant load, diminishes with increase of V, and varies from 0.0198 at 4 m. to 0.003 at 10 m. per sec. To obtain the available energy the value of T in the above formula must be multiplied by a factor varying from 0.2 to 0.4 according to the nature and condition of the mill.